

Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

LEWIS
1.9
0691Rp

TWENTY~~TH~~-FIRST ANNUAL REPORT
of
Pasture Research
in the
Northeastern United States
State College, Pennsylvania
1957



FOR ADMINISTRATIVE USE ONLY

1957

Twenty-first Annual Report

of

Pasture Research

in the

Northeastern United States

U. S. Regional Pasture Research Laboratory
State College, Pennsylvania
Forage and Range Research Branch
Crops Research Division,

Eastern Soil and Water Management Research Branch
Soil and Water Conservation Research Division,

and

Field Crops Insects and Bee Culture Research Branch
Entomology Research Division

of the

Agricultural Research Service
U. S. Department of Agriculture

and

The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

- - - - -

Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition to some institutions outside the Region where grassland research is a major interest.

For Administrative Use Only

B.

THE LABORATORY STAFF

H. L. Carnahan	Agronomist in Charge
Lois L. Smith	Secretary

Project Leaders

H. L. Carnahan	Breeding and Cytogenetics
J. H. Graham	Plant Pathology
A. W. Hovin	Cytogenetics of Legumes
R. C. Newton	Entomology
C. L. Rhykerd	Soils
V. G. Sprague	Agronomy
J. T. Sullivan	Plant Chemistry

Assistants

Mary L. Denison	Plant Chemistry
Charles F. Gross	Soils
Helen D. Hill	Cytogenetics
Galen A. Motter	Agronomy
K. E. Zeiders	Plant Pathology

Part-Time Assistants

T. G. Phillips (at New Hampshire)	Plant Chemistry
-----------------------------------	-----------------

COLLABORATORS

B. A. Brown, Connecticut	R. P. Murphy, New York
C. S. Brown, Maine	C. E. Phillips, Delaware
W. G. Colby, Massachusetts	G. G. Pohlman, West Virginia
H. B. Couch, Pennsylvania	M. A. Sprague, New Jersey
A. M. Decker, Jr., Maryland	R. C. Wakefield, Rhode Island
H. A. Keener, New Hampshire	G. M. Wood, Vermont

194526

* * * * *

* This annual report of pasture research in the twelve *
* Northeastern States is a progress report and as such *
* may contain statements which may or may not be veri- *
* fied by subsequent experiments. The fact that any *
* statement has been made herein does not constitute *
* publication. For this reason citation to particular *
* statements in the report should not be published un- *
* less permission has been granted by the author. *
* *
* The report is prepared primarily for the official use *
* of forage crop research workers in the Region and *
* since it is reproduced in limited numbers, it is not *
* available for general distribution to individuals out- *
* side the Region. *
* * * * *

TABLE OF CONTENTS

Research at the Pasture Laboratory

	Page
Introduction	1
Genetics and pathology	2
Alfalfa	2
Selection for disease resistance	2
Progenies of rhizomatous and upright	3
Selection within root-spreading	4
Selection for resistance to leafhopper	5
Inbreeding	6
Ladino clover	7
Selection for persistence	7
Inheritance of leaf resistance	7
F ₁ and F ₂ yields	8
Factors affecting persistence	8
Gibberellic acid and damping-off	8
Pseudoplea diseases of legumes	9
Crown vetch diseases	10
Meadow fescue and perennial ryegrass	10
Intergeneric hybridization	10
Meiotic irregularities in <u>F. arundinacea</u>	11
Orchardgrass	11
Male-sterility	11
Selection for disease resistance	12
Entomology	12
Biochemistry, physiology, and soils	14
Carbohydrate studies on grasses	14
Measurement of nutritive value of pasture plants	16
Anthocyanin measurement in Ladino clover leaves	19
Plant climate	20
Temperature and plant growth	20
Legume seedling establishment	22
Phosphate solubility, placement, and temperature in relation to growth of red clover	22

Research at Beltsville, Maryland

Clover research	24
Grass research	25
Birdsfoot trefoil breeding	25
At Ithaca, New York	26
Foundation seed production	27
Investigations of genetic stability in seed of improved forage crop varieties	28

Reports of Cooperative Projects

NE-13 - The mechanization of forage crop harvesting, processing, storing, and feeding	29
NE-18 - Economics of forage production and utilization	33
NE-24 - The nutritive evaluation of forages	35
NE-28 - Breeding and evaluation of improved varieties of forage crops adapted to the northeast	38
NE-29 - Establishment and management of perennial forage species and varieties for persistent production in the Northeast	41

Pasture Research at State Stations

<u>Connecticut (Storrs)</u>	44
Alfalfa experiments	44
Fertilization	44
Varieties	46
Ladino clover longevity and yields	47
Use of herbicides in forage crop management	48
<u>Maine</u>	
Forage breeding and variety testing	50
Time and rate of nitrogen on grass	51
Time and rate of nitrogen on legume-grass	51
Rate of nitrogen, phosphorus, and potassium on timothy	51
Rate of lime, phosphorus, and potassium on legume-grass	52
<u>Maryland</u>	
Ladino clover breeding	52
Improvement of red clover adapted to Maryland	52
Orchardgrass breeding	53
Variety and strain testing of forage grasses and legumes	53
Nitrogen fertilization of pure grass and grass-legume associations . .	54
Response of orchardgrass to various rates and ratios of potassium and nitrogen fertilization	54
Time and rate of potassium application to alfalfa and alfalfa-orchardgrass	55

Maryland (Cont'd.)

Comparison of nitrogen sources on established bluegrass sod	55
Grass and legume combinations for beef production	55
Effects of irrigation and fertilization on five forage species grown on Monmouth loamy, fine sand soil	56

Massachusetts

Effect of N and K on yield, composition, and longevity of alfalfa with orchardgrass and ladino clover with orchardgrass	56
Insects in relation to forage crops	58

New Hampshire

Improvement of smooth brome grass, red clover, and alfalfa	59
Improvement of white clover	60
Preliminary investigation of forage insects	61
Soil fertility studies of forage crops	62
Water and fertilizer requirements of selected crops and soils as related to supplemental irrigation	62
Heavy fertilization and nutritive value of timothy	63
Economic evaluation of forage production and utilization	63

New Jersey

Genetics and breeding of forage legumes	64
Evaluation of forage strains and varieties	64
Yield and protein content of grasses fertilized with heavy rates of nitrogen	65
Fertilizer studies with alfalfa	66
Applied N and K, frequency of cutting and yield, quality and longevity of Atlantic alfalfa	67
Pasture renovation studies	67
Forage insects	68
Feeding value of high nitrogen grass	69
Horse pasture research	70
Preservation of surplus spring pasturage in plastic materials . . .	71

New York (Cornell University)

Breeding and cytogenetic investigations	71
Breeding and evaluation of improved varieties of forage crops . . .	73
Strain testing and breeding of forage plants with emphasis on production during midsummer drought	74
Birdsfoot trefoil improvement	76
Birdsfoot trefoil seed production	76
Diseases of forage crops	77
Birdsfoot trefoil culture and management	78
Factors affecting seedling establishment of forage crops	79
Entomology	79
Time of cutting and digestibility of forages	81
Development of indirect methods for measurement of digestibility and rate of consumption of feedstuffs, particularly forages, by ruminants	82
Maximum utilization of forages by livestock	83
Nitrate accumulation in forages	83

New York (Cont'd.)

Molybdenum and forage legumes	84
Storage of moist grain by means of fungicides	85
Foliar applications of urea on forage grasses and their effect on feeding value	86

Pennsylvania

Genetics and improvement of alfalfa	87
Genetics and improvement of red clover	87
Genetics and improvement of birdsfoot trefoil	88
Genetics and improvement of forage grasses	88
Cytogenetic studies of Phalaris hybrids	89
Introduction and evaluation of forage crops breeding stocks	90
Forage and grain production of winter small grains and management	90
Renovation of unproductive pastures	91
Stockpiling of forage on renovated pasture	92
Forage insects	93
Evaluation of grasses and legumes	94
Utilization of forage by beef cattle	94
Economic evaluation of pasture improvement and renovation	95

Rhode Island

Nitrogen fertilizers for grass and grass-legume forage mixtures . .	96
Breeding and evaluating alfalfa	97
Forage crop establishment studies	97
Nematodes associated with alfalfa	98

Vermont

Simulated management practices and several trefoil species and varieties	98
Forage crop insects	99
Birdsfoot trefoil meal for poultry rations	99
Consumption and utilization of forage by chickens	100

West Virginia

Smooth brome grass varieties	100
Alfalfa varieties	101
Nitrogen application on bluegrass	102

List of publications	103
--------------------------------	-----



PASTURE RESEARCH IN THE NORTHEASTERN UNITED STATES

This report, the twenty first in the series, was prepared by and is intended primarily for the use of personnel engaged in forage crop research in the twelve Northeastern States. It contains a brief summary of progress during 1957. Included are activities of the Pasture Laboratory, of the various forage crops technical committees, of the state experiment stations and of the Forage and Range Research Branch in Beltsville, Maryland. The Collaborators assembled and edited material from their respective stations, the chairmen of regional technical committees supplied copies of their annual reports, and project leaders at the Pasture Laboratory and section heads at Beltsville prepared descriptions of their research.

There were a number of personnel changes at the Pasture Laboratory during the last year. Research assistants, Samuel W. Braverman and Douglas G. Routley completed work for the Ph.D. in plant pathology and biochemistry, respectively. Dr. Braverman is now with the Plant Introduction Station at Geneva, N.Y. while Dr. Routley is a member of the Chemistry (Agr. and Biol.) Department at The University of New Hampshire. Mrs. Eleanor L. Rowland, assistant in Plant Chemistry has been replaced by Mrs. Mary L. Denison. Dr. T. G. Phillips was employed to work part-time at New Hampshire on the chemistry of forages. Mr. Kenneth E. Zeiders replaces Mr. John A. Chemsak as assistant in Plant Pathology. Dr. Charles L. Rhykerd, a recent graduate of Purdue University, has assumed the leadership of the soils project. Dr. Arne W. Hovin, who completed his work at UCLA in 1957, will head the legume cytogenetics project. Dr. Howard L. Carnahan will continue as project leader in breeding and grass cytogenetics while serving as Agronomist in Charge of the Pasture Laboratory.

Dr. M. A. Farrell resigned as Collaborator from the Pennsylvania Agricultural Experiment Station and has been replaced by Dr. Houston B. Couch.

RESEARCH AT THE PASTURE LABORATORY

GENETICS AND PATHOLOGYAlfalfa

Selection for Disease Resistance

The program of introducing foliar disease resistance into Vernal and into selected Pasture Laboratory material is being continued (1956 Annual Report, pages 5-6). In spring 1957, approximately 15,000 seedlings, representing selfs, intercrosses, and second generation backcrosses, were screened in the greenhouse for resistance to foliar diseases and reduced approximately 50 percent. Before transplanting to the field, roots of the seedlings were cut and a suspension of Cornebacterium insidiosum was poured over them.

Plants in the disease nursery were at one foot spacing with Lahontan in every fourth row. During the summer and fall, all plants were rated for disease. Lahontan was attacked severely by rust. As listed below, 332 plants were brought into the greenhouse in the fall.

	No. Seedlings <u>Started</u>	No. Selected <u>in Field</u>	No. Finally Selected for <u>Crossing</u>
Second BC to Vernal	1700	108	31
Second BC to P.L. Selections	1200	73	14
Intercrosses	1200	34	15
Inbreds	1000	66	14
Introductions	200	5	1
Vernal	800	46	10
Lahontan (Susc. checks)	<u>2000</u>	<u>0</u>	<u>0</u>
Totals	8100	332	85

The number for crossing and selfing was reduced to 85 by considering the following factors: vigor, color, viruses, bacterial wilt, and foliar diseases. About 5 percent developed bacterial wilt. The third backcross generation, selfs, and various intercrosses will be established in the field in spring 1958.

When it appears that genes for resistance are sufficiently concentrated, lines will be grouped for seed increase for plot evaluation.

Comparison of Progenies of Rhizomatous and Upright Alfalfa Selections

In 1953 restricted polycross progenies of 6 rhizomatous and 6 related upright clones were set into plots with individual plants on one-foot squares and plots 5'x16'. The six replications were over-seeded with S-37 orchardgrass. On three replications, a hay (3-cut) management was used and on the other three replicates, a simulated grazing management (4 cuts at early bud stage) was imposed. The object was to determine whether the rhizomatous or so-called "grazing" types would hold up relatively better under the more severe cutting schedule than would the upright types. The relative performance of the various strains could be evaluated at the same time. The two wilt susceptible varieties, Rhizoma and Narragansett and the wilt resistant variety, Buffalo, were included as checks.

The "rhizomatous" progenies only crept moderately in this experiment, were somewhat slower in recovery following each harvest, and were more susceptible to leaf diseases than the check varieties. The broader-crowned varieties, Rhizoma and Narragansett performed better than the narrow-crowned Buffalo in the 1' spacing in the early years of the test. Buffalo, has performed relatively better during the last two years and this appears to be related to its resistance to wilt in contrast to the other two varieties. This points to the need for wilt resistance in "grazing alfalfas" where stands may be expected to remain down for several years.

The combined analysis for all years of this experiment has not been run. Analysis of the 1955 results, however, shows significant differences due to strains, managements, strains x managements, cuts (1st vs. total aftermath), cuts x strains and cuts x managements. The CxSxM second order interaction was significant for the alfalfa fraction but not for alfalfa plus grass. The strains x managements interaction was not due to the rhizomatous strains performing relatively better at the frequent cutting schedule than the upright strains but rather, the more rapidly recovering strains appeared to be hurt less by frequent cutting than were the slower recovering strains. There was striking variation in performance within both groups of progenies.

Continuous harvesting at the early bud stage tended to weaken the plants in contrast to those harvested at the 1/10 bloom stage.

Selection within Root-Spreading Alfalfa Populations

From a source nursery of about 10,000 spaced plants from three seed lots of Canadian root-spreading alfalfa established in 1955, 61 selections were made in 1956 on the basis of resistance to *Pseudopeziza* and *Ascochyta* and on rapidity of recovery following clipping. It could not be determined at that time whether or not selections were spreading. These 61 selections were cloned and established in four replications with 5 plants of each clone per replicate. Two replicates were overseeded with timothy and the other two cultivated in order to obtain information on the effect of the competing grass on rate of spreading of the alfalfa.

In 1957, the majority of the clones were much inferior to a Vernal check clone in rate of recovery following clipping. Only 32 of the 61 selections gave evidence of root-spreading in the year of establishment from cuttings. Vigor of clones was rated from 1 to 10 with 1 best. Rambler check rows rated 6.0 for vigor compared to an average of 4.1 for the selections thus indicating average progress from selection. Some of the better spreading clones and their vigor are listed here and indicate the potential within this material.

<u>Clone</u>	<u>9-25-57 Vigor</u>	<u>9-25-57 No. of shoots from spreading roots</u>
56-124	2.75	4.25
56-128	2.50	15.25
56-129	3.25	3.75
56-133	3.75	3.50
56-137	3.50	4.00
56-138	3.25	5.00
56-140	2.50	34.00
56-144	4.00	6.25
56-145	4.75	10.75
56-151	2.25	15.25
56-153	3.25	6.75
56-154	4.75	16.00
Rambler (check seedlings)	6.00	4.75
Vigorous Vernal clone	1.75	0.00

Some of the better of these clones are being intercrossed and crossed onto a New York root-spreading clone with good seedling vigor. This material will be used for another cycle of selection in an attempt to develop root-spreading alfalfas adapted to northeastern conditions.

It is our belief that adapted root-spreading alfalfas may play a prominent role in extending the alfalfa acreage in the region. There are thousands of imperfectly drained acres where it is now possible to get only a 15 to 20 percent stand of alfalfa due to heaving. It appears that a 15 to 20 percent stand of good root-spreading alfalfa would fill in to produce an economic stand on such areas and might be less subject to heaving as a consequence of its root system. Since alfalfa is the most productive legume for the region wherever it can be grown, alfalfas on these imperfectly drained areas would make a significant contribution to the agriculture of the region.

About 2300 seedlings representing intercrosses among selections from the Canadian source, I_1 's from rhizomatous clones, and intercrosses between rhizomatous and root-spreading sources were established in 4'x4' spaced plantings in 1957 for further selection.

Selection for Resistance to Leafhopper

Individual plant leafhopper readings (1-10) were taken on about 10,000 spaced plants representing three lots of Canadian root-spreading alfalfa. Most of these plants were non-spreaders. A few plants were rated one (best), whereas many were rated nine or ten during the heavy leafhopper infestation. The correlation between readings made on 3801 plants at different dates was +0.76, thus indicating fair consistency in yellowing at different dates and reliability in scoring procedure. Sixteen of the most "resistant" plants and 10 of the more susceptible plants have been cloned for establishment in four replications of 5 plants per clone per replicate in 1958. This planting will be studied carefully in an attempt to ascertain whether "resistance" is due to failure of the plant to turn yellow even when heavily attacked; differential in degree of natural infestation; differential ability of leafhopper nymphs to survive on various clones; or other possible effects.

The parental clones of Moapa alfalfa and unselected plants of African have been started in the greenhouse and will be transplanted in 1958 for a comparison of reaction to leafhoppers. The Moapa clones are resistant to the spotted alfalfa aphid, whereas the African plants are not. It is hoped that we can learn whether the factor or factors which convey resistance to aphids will give any resistance to leafhoppers.

The greenhouse partition was completed in March 1959 and will permit more extensive controlled entomological work next year. We plan to test large populations of alfalfa seedlings to leafhopper reaction if suitable techniques can be developed for artificially rearing the insects.

Inbreeding Alfalfa

From a spaced-plant nursery established in 1953, 13 first generation inbred plants that outyielded their respective mother clones were propagated vegetatively with the 12 mother clones and established in 5-plant spaced-plant rows in four replications in a 5'x5' simple lattice. It is commonly stated that the F_2 or I_1 population may vary in genetic vigor potential from a low of the inbreds to the high of the F_1 . In plants with tetrasomic or partially tetrasomic inheritance and with incomplete dominance, one may visualize that a heterozygous clone could be Aaaa for several loci with major effects on vigor. It should theoretically be possible to obtain some I_1 plants with the genotype AAAA. Such selected plants, assuming incomplete dominance and assuming concurrent selection for other loci might be expected to exceed the F_1 or mother clone in vigor or yield potential. Perhaps of greater significance, however, is that the combining ability of such plants should also theoretically prove superior to that of the parent.

The test established in 1957 was designed to (1) determine whether selected I_1 plants exceed the parent clones in vigor, and (2) obtain heritability estimates for yield from spaced-plant nurseries. If certain inbred selections outyield their parents, their combining abilities will then be compared in subsequent tests.

The selfed progeny of a plant, used in the disease resistance study, segregated about 3:1 for normal vs. albino seedlings. Dr. Arne Hovin plans to follow the inheritance of this trait and to treat the parental clone with colchicine to see whether somatic segregation and homozygous chimeras can be induced as has been reported for certain grain sorghums. If this can be achieved, the genetics of alfalfa could be developed with such material with considerably more certainty than it has been to date.

Ladino Clover

Selection for Persistence

The 1956 space-planted source nursery consisting of single-crosses among clones selected for *Sclerotinia* resistance and among clones with persistence at low light intensity was maintained without cultivation in 1957. The nursery was clipped frequently to keep reseeding to a minimum and to control weeds. Individual plants grew together to a considerable extent but it was felt that the more persistent plants could be identified in the spring of 1958 i.e. following the second winter when loss of stands is commonly severe. Selections will be made in spring of 1958 though most, if not all, plants appear to be infected with virus.

Three replicates of 5-plant rows of each of 67 clones selected in 1957 from the 1956 source nursery were planted for further observations on persistence. A prolonged drought was detrimental to this planting.

Ground cover (clover) of polycrosses of 53 Ladino clones and 11 checks two years following establishment with brome grass and with orchardgrass varied from a low of 4.24 percent for Idaho Common to a high of 58.2 percent for one polycross. Pilgrim averaged 38.5 percent compared to 51 percent for the Iowa synthetic. Only 2 of the 53 polycrosses were significantly more persistent than Pilgrim. In this test following the second winter, the average percent clover ground cover for all strains seeded with orchardgrass was 21 percent compared to 54.6 percent for the same strains seeded with brome grass. This emphasizes the lack in persistence of Ladino. Original stands were excellent. Furthermore, the relatively narrow range in performance among polycrosses suggests that major improvement in persistence of Ladino through breeding is not to be expected in the near future.

The N.E. 28 Ladino strain and polycross tests were established in plots with fair stands.

Inheritance of Leaf Markings

From F_2 and testcrosses, it has been found that the red-V marking in white clover is conditioned by a single factor dominant to no marking. All plants with the red-V also had the white-V marking, so we do not know whether the red-V allele is closely linked with the white-V locus or is merely another allele of the white-V locus. Additional work is planned to see whether the recombination type can be obtained. This genetic marker should prove useful in future genetic and/or seed certification studies.

F₁ and F₂ Yields of Trifolium repens

This experiment (1956 Annual Report, page 7) was continued in 1957. Average yields of clover and brome grass on F₂ plots was 90.2 percent of those on F₁ plots. The corresponding value in 1956 was 87.3 percent.

Factors Affecting Persistence of Ladino White Clover

A field experiment was set up in April 1956 to determine some of the factors involved in stand depletion of Ladino white clover. This test consists of 78 5'x10' plots seeded with Pilgrim clover and Common orchardgrass with 3 main plots, 6 sub-plots, and 4 replications. The main plots entail 3 managements (1) early and frequent cutting program that favors the clover, (2) same as (1) except flowers were removed to prevent any natural reseeding, and (3) late cut which favors the orchardgrass. Sub-plots are as follows: (1) soil fumigated with Vapam before seeding and weekly application of various fungicides and insecticides, (2) fumigation only, (3) no treatment, (4) introduction of *Pseudoplea* into plots, (5) introduction of virus, and (6) introduction of *Pseudoplea* and virus.

In 1956 and 1957 observations were made on stand and vigor of the clover. During 1956 the orchardgrass was taller and darker green while the clover was smaller in fumigated plots. By 1957, the clover in the fumigated and sprayed series was thicker and more vigorous than in other plots. The vigor ratings taken in June were 9.5 for fumigated plus sprayed plots; 7.0 for fumigated only plots; and 6.4 for the other plots. Insect populations were much lower in the sprayed plots and leaf diseases were slightly less prevalent. Differences were not evident among the other treatments in the test. Greater differences should be noted in 1958, after the second winter.

Effect of Gibberellic Acid on Damping-Off of Ladino White Clover

During 1957 two tests were conducted in the greenhouse to determine the effect of gibberellic acid (placed on seed) on the susceptibility of Ladino to pre- and post-emergence damping-off. Four treatments, consisting of steamed soil and soil infested with *Pythium*, *Rhizoctonia*, and *Fusarium*, and three concentrations of gibberellic acid (0, 10, and 40 p.p.m.) were used.

Treated seed emerged at a faster rate in steamed soil and young seedlings were taller in both the 10 and 40 p.p.m. treatments. In soil infested with *Pythium*, pre-emergence damping-off of seedlings from treated seed was greater than from seed receiving no acid treatment. In soil infested with each of the three fungi, post-emergence damping-off was approximately twice as severe when gibberellic acid was used as compared with the control indicating that gibberellic acid will not be useful in increasing stand establishment in this legume. Gibberellic acid had no effect on growth of the three fungi in culture.

The Pseudoplea Diseases of Legumes

Morphological, physiological (including cultural), and pathological studies have been completed on collections of *Pseudoplea* from alfalfa and Ladino white clover. Isolates from red clover, alsike clover, sweet clover, and black medic were used in comparative tests. In the studies, collections of isolates were obtained from Georgia to New Hampshire.

The isolates of *Pseudoplea* could be separated according to ascospore morphology on V8 agar. Ascospores from alfalfa ranged in size from 11-19 μ x 37-53 μ . The average number of septa was higher for isolates from alfalfa than from Ladino. Ascospores from isolates made from the other hosts (with the exception of sweet clover) were similar morphologically to those from Ladino clover.

The same isolates differed in the type of colony produced on V8 agar. All isolates from alfalfa formed large colonies (average size 32 mm in 8 days) with white to gray aerial mycelium and many perithecia scattered throughout. Isolates from Ladino, alsike, red clover and black medic produced small colonies (average 15 mm) with little aerial mycelium and numerous perithecia clumped together. The one isolate from sweet clover formed a large colony (30 mm) consisting of black mycelium and perithecia.

Isolates from Ladino clover and alfalfa were similar in response to temperature in laboratory studies. The optimums for perithecial formation, ascospore discharge, and disease development were between 15°-22° C.

In tests using 8 sources of nitrogen in liquid media there was as much variation among isolates from one host as between isolates from two hosts.

Although under ideal conditions in the greenhouse, *Pseudoplea* from alfalfa can infect Ladino clover and vice versa, infection is more severe on the original host. Some isolates did not cross infect.

In contrast to reports in the literature, an asexual stage (*Stemphylium*) was not associated with *Pseudoplea*.

The present studies indicate that *Pseudoplea* from alfalfa is closely related to but distinct in some characteristics from *Pseudoplea* from Ladino white clover. The following designations are tentatively proposed:

Pseudoplea briosiana var. *briosiana* on alfalfa.
Pseudoplea briosiana var. *trifolii* on Ladino white clover,
 red clover and alsike clover.

Crown Vetch Diseases

Before research on miscellaneous legumes was discontinued, plantings of crown vetch had been examined for disease. A report of this work was published in 1957.

Cercospora rautensis (first report in U.S.) was moderately severe on leaves and stems. Anthracnose (*Glomerella cingulata*), not previously reported on crown vetch, was present in some plantings. Two unknown species of *Stemphylium* were also observed. One, somewhat similar to *S. solani*, was pathogenic while another small-spored type was not pathogenic. The sexual stage (*Pleospora* sp.) of the latter was found. Further work is planned on the two species of *Stemphylium* in relation to other *Stemphyliums* on legumes.

Meadow Fescue and Perennial Ryegrass

Intergeneric Hybridization

Plantings of this material (1956 Annual Report, page 9) were established in 1957 and cytological collections made from those materials that headed. The cytological collections will be completed and studied in 1958. "Seed" was harvested from 35-chromosome clones of [*L. perenne* x *F. elatior* (4x)) x *F. arundinacea*] that had been treated with colchicine. Heads were also harvested from 28-chromosome progenies derived from the original triploid intergeneric hybrids. Selection will be continued for fertility and desirable agronomic characteristics in this material.

Chromosome numbers were determined in L. multiflorum x F. arundinacea F_1 hybrids, backcrosses to F. arundinacea, and amphiploid derivatives. This material was produced by Robert Buckner of Kentucky. F_1 hybrids possessed the expected complement of 28 chromosomes. First, second, and third backcrosses to tall fescue had 35 to 42 chromosomes, whereas all plants of the fourth backcross generation examined had 42 chromosomes. One seedling progeny derived from the colchicine-treated F_1 had 42 chromosomes, one had 56, and two had 70 chromosomes. No good pollen was produced by any of the backcross progenies studied. Meiosis of those few studied was characterized by more univalents, stickiness and micronuclei than in tall fescue. Pairing of chromosomes in the F_1 hybrids was better than expected, with a few cells having no univalents at MI. This indicates pairing between *Lolium* and *Festuca* chromosomes as well as pairing between *Festuca* genomes.

Meiotic Irregularities in F. arundinacea

A clone of tall fescue used as a parent in intergeneric hybridization shows anaphase bridges at meiosis characteristic of inversion heterozygosity. The question arises whether it is heterozygous for the inversion in one pair of homologous chromosomes or whether the bridges are formed as a consequence of a certain degree of homeologous pairing. An answer to this question would be of considerable interest to breeders of such polyploids. An I_1 population has been produced and will be analyzed for inversion heterozygosity. Frequency of I_1 plants with inversion heterozygosity should give a clue to the basis of this behavior.

Orchardgrass

Male Sterility in Orchardgrass

Crosses between male-sterile and male-fertile orchardgrass sibs and self-pollinated male-fertile segregates were planted and pollen checked on those plants which flowered. The population analyzed so far is too small to permit genetic interpretation. Pollen analysis to date, however, indicates a range of 0 percent to 89 percent "good" pollen among plants, with several intermediate classes. This is suggestive of quantitative inheritance. Chromosome counts in male-sterile plants indicate that many, if not all, are hyperaneuploid. Differential rates of transmission of extra chromosomes in male and in female gametes might give results that would also fit those expected from cytoplasmic-genic interaction. The quantitative nature of male-sterility, however, would not appear to fit with the interpretation of aneuploidy as the basis of male-sterility. Additional work is planned to further elucidate the nature of male-sterility in orchardgrass. Whether or not this male-sterile source can be transmitted into a desirable genetic background and used for producing hybrid strains is dependent on a knowledge of the genetic basis of this character.

Selection for Disease Resistance in Orchardgrass

Polycross progenies of 11 clones along with S-37, Potomac, and a synthetic "R" from four clones selected for resistance to leaf diseases were harvested and noted in 1957. In yield, polycrosses of MX-7 were highest (4.12) compared with 4.06 for Potomac and 3.66 for "R". On the other hand, MXL-17 had the lowest reading (3.5) for leaf diseases (mainly streak and purple leaf spot) compared with 6.9 for Potomac and 5.4 for "R" with a between strains L.S.D. of 1.45. Differences in yield between Potomac and "R" appeared to be related to differences in maturity of the two strains as the later maturing entries tended to yield somewhat less than the earlier maturing entries.

ENTOMOLOGY

The alfalfa weevil has continued to spread in the Northeast. It was found for the first time in Connecticut and Massachusetts. Thirty-five new counties were found infested as follows: West Virginia 7, Pennsylvania 10, New York 9, Connecticut 7, and Massachusetts 2. Serious damage to first crop alfalfa occurred in untreated fields in the older infested areas.

The spotted alfalfa aphid spread at a much slower rate in 1957 than was expected. No additional infestations were reported in West Virginia and it was not found in any other Northeastern States. Weather conditions and natural enemies probably were responsible for the slower spread in the east.

A periodic survey of a red clover, an alfalfa, and a Ladino clover and brome-grass field showed the most abundant leaf-feeding insects to be spittlebugs, several different plant bugs, pea aphids, and the potato and other leafhoppers. Important root-feeding insects in red clover were clover root curculios and clover root borers, while the clover root curculio was the dominant root-feeding insect affecting alfalfa and Ladino clover. Although the alfalfa weevil was present in a few State College alfalfa fields, it did not infest the University or U. S. Pasture Laboratory alfalfa nurseries this season.

A number of insects were examined for possible vectors of disease incitants. An overwintering immature clover leaf weevil contained the leaf and stem pathogen Colletotrichum within its body. The adult leafhopper Macrostelus fascifrons swept from an alfalfa field and from a red clover field was found to carry a virus tentatively identified as bean yellow mosaic. Millepedes present in the soil around red clover, alfalfa, and Ladino clover carried Fusarium both within and on their bodies.

The root-spreading alfalfas were examined for plants resistant to spittlebugs and to potato leafhopper yellowing. These same plants will be checked again this coming season so that any promising material may receive further study.

A study was initiated to determine the relationship of Fusarium and root-feeding weevils on length of red clover stands. Fifty insect- and disease-free plants, with the equivalent of one year's growth because they were started in the greenhouse, were space-planted in field plots in May 1957. Part were planted in fumigated (Vapam) soil and later dusted with heptachlor and part in non-fumigated soil. No insect or root injury, and very few darkened areas, occurred in the treated area while all plants examined in the untreated area had evidence of both insect and disease injury.

A second experiment with potted red clover plants, started in the greenhouse in October 1957, is now in progress. It consists of 16 treatments and 4 replicates of caged adult clover root curculios, caged adult clover root borers, mechanical injury and Fusarium spp. separate and in combination using both steamed and non-steamed soil. Plants infested with insects showed some growth differences prior to first cutting. The recent emergence of new clover root curculios indicates that some progeny of the original weevils completed their life cycle on the infested plants.

Adult root borers spend much of their lives within red clover roots and crowns but have a flight period each spring which permits them to infest new fields. A 4'x16' sticky painted structure was used to determine adult clover root borer migrations. It caught 126 weevils from April 26 to June 6 with greatest activity comprising 44 percent of the total catch occurring May 8 to 16. Forty-two of the migrating borers were plated for Fusarium. Three non-sterilized borers in 3 different platings or about 7 percent of the migrating beetles were carrying this organism.

In greenhouse studies at Beltsville conducted cooperatively by G. R. Manglitz and K. W. Kreitlow, a positive transmission of alfalfa mosaic in Ladino clover was obtained using the clover aphid, Anuraphis bakeri.

BIOCHEMISTRY, PHYSIOLOGY AND SOILS

Carbohydrate Studies on Grasses

(In cooperation with the New Hampshire Station)

Studies on the carbohydrates of grasses have been underway for some years in cooperation with the New Hampshire Station. At present, emphasis is being placed on hemicellulose.

An intensive study was made on two clones of bromegrass. The first sampling made at the boot stage was divided into leaves, stems, and roots, the second at flowering into leaves, stems, roots, and heads, and the third, aftermath, was foliage only. The relative amounts of the different constituents in the different parts of the plant are of interest and are given in Table 1. It is to be noted that both cellulose and hemicellulose increased in the leaves and stems between the boot and flowering stage but decreased in the roots during the same period. The order of increase or decrease was the same for hemicellulose as for cellulose so that the relative proportions of these two related substances did not change.

For detailed study of the hemicelluloses, the procedure was as follows: The holocellulose, which consists of the cellulose and the hemicellulose was first prepared from each of the above samples. This was done by treating the ground plant material with a mixture of benzene and alcohol to remove lipids, then with pepsin to remove protein, with ammonium oxalate to remove pectin, and finally with sodium chlorite to remove lignin. The material remaining is holocellulose and the next operation is to remove hemicellulose from this. The polyuronide hemicelluloses may be removed by prolonged action of boiling water in which the hemicelluloses are soluble, though they were not soluble in water in the original plant material, but the lignin has now been removed. The solutions of polyuronide hemicellulose are purified by dialysis and the hemicelluloses precipitated out by alcohol. After no more hemicellulose can be removed from the holocellulose by water, other hemicelluloses, xylans and glucosans, were removed by cold alkali. These contained no uronic acid and are called in general cellulosans. They also were dialyzed and precipitated from solution by alcohol.

The two types of hemicellulose, the polyuronide hemicellulose and the cellulosans, were separately hydrolyzed by sulfuric acid into their components which were separated by paper chromatography and determined quantitatively by a micro sugar method. In the polyuronide hemicelluloses were found four sugars, xylose, arabinose, glucose, and galactose, in order of decreasing abundance, and two uronic acids, glucuronic and galacturonic. In addition to these six components, five spots, at first unknown, on the chromatographs, were later identified as aldobiuronic acids. An aldobiuronic acid contains two units

Table 1. Composition of bromegrass plants, from which hemicelluloses were prepared, in percent of dry matter.

Plant part	Stage of growth	Hemi-cellulose	Cellulose	Protein	Ash	Lignin
Leaves	Boot	14.2	26.4	18.3	8.7	6.2
	Flowering	17.2	28.4	12.5	8.4	6.9
Stems	Boot	23.2	34.3	7.2	6.5	6.7
	Flowering	28.7	39.5	2.8	4.2	11.7
Roots	Boot	27.2	32.4	4.6	10.9	16.2
	Flowering	24.9	30.4	4.0	9.4	15.6
Heads	Flowering	24.1	25.2	13.1	4.7	11.4
Leaves	Aftermath	15.6	29.6	13.0	9.1	6.7

(sugar or uronic acid) and their identification will aid in identifying the linkages that may occur in the complex hemicellulose molecule. They were identified by extracting them from the chromatographic paper, subjecting them to further acid hydrolysis, as they escaped from the first being very resistant to acid hydrolysis, and again chromatographing the components. The five aldobiuronic acids in bromegrass were identified as follows:

1. 2 mols. of galacturonic acid.
2. Glucuronic acid and galactose.
3. Glucuronic acid and xylose.
4. Galacturonic acid and rhamnose.
5. Methylglucuronic acid and xylose.

The first was not found in the roots and may have been derived from pectin rather than from hemicellulose. Work done on other grasses subsequent to that on bromegrass indicated that rhamnose was present in other grasses and is probably present in bromegrass also but was not detected at the time. The hemicelluloses which were removed by alkali (the celluloses) contained only two sugars in any considerable quantity, xylose and glucose, and no uronic acids. The quantitative results appear in Table 2. The sugars are expressed in percentage of total sugar. Uronic acids amounted to about 8 percent of the total and the individual ones were not determined quantitatively. This work

was done at the Pasture Laboratory, with the exception of the identification of the aldobiuronic acids which was done at the New Hampshire Station.

A less intensive study was made on 5 other grasses. The methods were essentially the same. The preparation of the hemicelluloses were made at the Pasture Laboratory and their analysis at the New Hampshire Station.

Rhamnose was identified as a component sugar in all samples and is probably present in brome grass also. The average percentages of the 5 sugars present in the water-extractable hemicelluloses, which is the major portion of the total hemicellulose, are given in Table 3. In addition there are present two uronic acids, totalling about 5 percent of the whole. The quantitative results are similar in all species, with few exceptions, considering that the precision of the analyses is not high. Orchardgrass appears to be higher than other grasses in glucose and correspondingly lower in xylose. Xylose predominates in all.

Quantitative recovery of the hemicelluloses from grass has not been attained. Small losses were demonstrated during the digestion of the grass with pepsin and greater losses during treatment with chlorite. During the extraction of the hemicellulose with hot water some simple sugars were removed which indicates that a partial hydrolysis of the hemicellulose occurred. The nature and extent of those losses are being studied. Partial and step-wise hydrolysis of the hemicelluloses while still attached to the holocellulose are being carried out with the expectation that the identification of the sugars and the order in which they are released will give clues as to the structure of the hemicellulose.

These studies of hemicellulose and proposed future studies of cellulose are being made in order to give basic information which may be used in understanding nutritive value and palatability of different forages.

Measurement of Nutritive Value of Pasture Plants

It is the object of this research to uncover information that would allow the chemist or agronomist to evaluate forages by chemical analysis or other laboratory technique. Forages of known digestibility have been supplied by the Pennsylvania, Massachusetts, Delaware, and Maryland Stations with the aid of the N.E. 24 Technical Committee. Analyses are being made of these samples and the results studied in relation to digestibility data.

Table 2. Sugar content of hemicellulose preparations, in percent of total sugars. Average of 2 clones. T = Trace.

Extracting medium	Stage of growth	Galactose	Glucose	Arabinose	Xylose
L E A V E S					
Water	Boot	5.9	8.7	12	74
	Flowering	5.9	6.3	11	77
Alkali	Boot	T	34	T	66
	Flowering	T	25	T	75
S T E M S					
Water	Boot	4.6	14	7.4	74
	Flowering	3.2	9.0	4.6	83
Alkali	Boot	T	33	T	67
	Flowering	T	19	T	81
R O O T S					
Water	Boot	11	6.5	13	70
	Flowering	13	6.5	13	68
Alkali	Boot	T	25	T	75
	Flowering	T	23	T	77
H E A D S					
Water	Flowering	4.4	5.9	7.8	82
Alkali	Flowering	T	17	T	83
A F T E R M A T H					
Water	—	7.4	17	11	65
Alkali	—	T	38	T	62

Table 3. Average amounts of sugars in water-extractable hemicellulose, in percent of total sugar.

	No. of Samples	Rhamnose	Galactose	Glucose	Arabinose	Xylose
Orchardgrass	14	1.8	7.2	22.4	12.8	55.7
Reed canary	4	1.0	6.4	12.6	11.1	68.9
Fescue	2	1.6	4.7	11.1	9.6	72.9
Timothy	2	0.9	4.8	16.3	9.1	68.9
Kentucky blue	2	1.5	6.8	12.2	12.2	67.3

A lignin determination or a combination of a lignin determination and ether and alcohol fractionation allows an estimate of digestible dry matter or digestible organic matter. The mathematical relationship between the lignin content of grass and digestibility held for any species of grass studied. The same relationship did not hold in alfalfa. A better mathematical relationship is being sought which can be used in all forages, grass, alfalfa hays, grass-legume mixtures, and silages. The number of samples on hand of these different classes is not sufficient for conclusive studies.

Alfalfa as a rule is higher in lignin than grass, and alfalfa is usually higher in digestibility than grass of the same lignin content. Some examples are given in Table 4. Samples 1 and 2 are a grass and an alfalfa of approximately the same lignin content (9.1 and 9.2) but the alfalfa has the higher digestibility of total organic matter (59.3 and 65.3). This may be partly explained in that alfalfa is higher in alcohol-soluble matter (17.1 and 24.7) which is of high digestibility and is lower in insoluble matter (79.8 and 73.2). Since the lignin occurs entirely in the insoluble portion it is more concentrated in the insoluble portion of the alfalfa than in the insoluble portion of the grass (12.0 and 13.8), but nevertheless the digestibility of the insoluble portion is higher in the alfalfa than in the corresponding portion of the grass (51.2 and 55.6). This higher digestibility of the insoluble portion of the alfalfa, in spite of its higher lignification, must be due to the higher digestibility of the alfalfa protein because the digestibility of the nonprotein portion of the insoluble fractions are alike in these two forages (55.2 and 55.1). As a result of such observations, studies are being carried out on the protein and nonprotein contents of insoluble portions of forages.

In Table 4 another pair of forages, a grass and an alfalfa (samples 3 and 4) have similar lignin concentrations in the insoluble portions (12.7 and 12.8), even though the lignin contents of the whole forages are not as close (9.6 and 8.6). Although the insoluble portions have the same lignin contents, that of alfalfa is the more digestible (51.0 and 57.5). The nonprotein portion of the insoluble fraction is also more digestible than that in the grass (52.9 and 54.6), which indicates that some other factor than lignin only affects the digestibility of cell wall carbohydrates. Lignin gives a fair evaluation among grasses and also perhaps among legumes but the same criterion cannot be used for both or for mixtures.

More materials for this study are becoming available and other stations will contribute forage samples of known nutritive value. A handicap to the solution of this problem is the lack of a precise and accurate method for the determination of lignin. Efforts are being made to improve the procedure for the determination of lignin.

Table 4.

	1. <u>Timothy</u>	2. <u>Alfalfa</u>	3. <u>Timothy</u>	4. <u>Alfalfa</u>
Digestibility of organic matter	59.3	65.3	60.0	66.6
Lignin, in % of dry wt.	9.1	9.2	9.6	8.6
Alcohol soluble matter, %	17.1	24.7	18.2	23.6
Alcohol insoluble matter, %	79.8	73.2	79.4	74.6
Lignin, in % of alcohol insoluble	12.0	13.8	12.7	12.8
Digestibility of alcohol insoluble	51.2	55.6	51.0	57.5
Digestibility of nonprotein portion of alcohol insoluble	55.2	55.1	52.9	54.6

Anthocyanin Measurement in Ladino Clover Leaves

Absorption spectra were prepared from three extracts, prepared by extracting anthocyanins from clover leaves with dilute hydrochloric acid.

1. A clone with wine-colored leaves.
2. A clone with a V-shaped wine-colored marking, the colored area being cut out and the area containing chlorophyll discarded.
3. The same clone as 2, the whole leaf being extracted.

The absorption spectra of 1 and 2 seemed identical, with an absorption minimum in each at 420 $m\mu$ and a maximum in each at 510 $m\mu$. Sample 3 was different with an absorption minimum at 460 $m\mu$ and a maximum at 510-520. The chlorophyll-containing areas in 3 contributed something to distort the spectrum obtained.

Plant Climate

Microclimate studies (1956 Annual Report, page 15) were continued. During the growing period of April 1 to October 31, air temperatures were 2 degrees above normal in April, May, and June; normal in July and September but 1 and 3 degrees below normal in August and October. Precipitation was above normal in April and June, and over two inches below normal in May, July, and August. Relative humidity averaged 10 percent higher in June than in the other months of April to October. Soil did not warm appreciably until the last two weeks in April and during the summer of 1957, soil temperatures were approximately the same as in the previous 4 years.

Observations were taken from atmometer bulbs placed as before at three locations: 5 feet above ground level and over Kentucky bluegrass, 3 inches above ground level and over bluegrass and at the same height in an alfalfa stand. These data indicated continual increase in daily evaporational water loss from the middle of May to the middle of August and then a daily decrease until the last of September. As in previous years, water loss was much less from the bulbs surrounded by alfalfa stems and leaves before cutting. Water loss was greatest from the bulbs placed at the 5-foot height.

Temperature and Plant Growth

Experiments here and elsewhere have been conducted to measure effects of temperature on plant growth. Due to technical difficulties in providing controlled temperatures that alternate from day to night in greenhouses or in small growth chambers, controlled temperatures have usually been maintained constant both day and night.

A preliminary test of seeds germinated in Petri dishes indicated only a small effect of alternating or constant temperatures except on the one species Kentucky bluegrass. "Germination" as used in this experiment, is defined as the stage of growth when a seed shows 1 mm or more growth of a root or plumule. For the legumes almost maximum germination of alfalfa occurred in 3 days, and of red clover in 4 days. Both Ladino clover and birdsfoot trefoil required 7 days for maximum germination. For brome grass and timothy, germination required 2 or 3 days longer than for alfalfa and red clover. Orchardgrass required 8 days longer. With Kentucky bluegrass, maximum germination had not occurred until the thirty-fifth day under alternating temperatures. At a constant temperature, the germination was about half as rapid. Alternating temperatures definitely increased the rate and total germination of Kentucky bluegrass.

In the first run of seeds planted in soil, the differential effects of alternating and constant temperatures were evident with orchardgrass, Kentucky bluegrass, birdsfoot trefoil and ladino white clover. With the other species little or no difference was apparent. Maximum emergence of ladino white clover, orchardgrass, and birdsfoot trefoil was higher and occurred sooner under constant temperatures. In contrast, emergence of Kentucky bluegrass occurred sooner and the total number of plants was greater under alternating temperatures.

In the climate chambers at the U. S. Pasture Research Laboratory, trials will measure plant growth under constant and alternating air and soil temperatures at 50, 60, 70, and 80° F. Under alternating temperature conditions, the daily range between maximum and minimum temperatures of either air or soil is 20 degrees.

The experiment includes studies under all four possible combinations of alternating and constant temperatures of air and soil. These include: (1) alternating air and alternating soil temperatures, (2) constant air and soil temperatures, (3) alternating air with constant soil temperatures, and (4) constant air with alternating soil temperatures. Under alternating temperatures, the maximum occurs at 2 p.m. and the minimum at 5 a.m.

Species being studied include four grasses (orchardgrass, brome grass, timothy, and Kentucky bluegrass) and four legumes (alfalfa, red clover, ladino white clover, and birdsfoot trefoil).

The soil used is a fertile greenhouse potting soil well limed and fertilized. Watering is checked daily to maintain soil moisture at about half of field capacity. Light is supplied by fluorescent lamps; one-half "white", and the other half an equal number of "daylight" and "pink" lamps. A fifteen-hour day is thus provided at a light intensity of 500 footcandles.

Temperature effects on dry matter production are being determined and should be available within the next year.

Legume Seedling Establishment

The studies (1956 Annual Report, page 17) were continued. To observe effects of climatic variables on seedling emergence of alfalfa and Ladino white clover, establishment studies were conducted during 1957. Duplicate rows of 100 seeds each were planted at 3-week intervals from April 22 to September 4. The number of days from the planting date to the time of maximum germination ranged from 8 days for the April seeding to 22 days for the mid-May seeding. Climatic records taken for this period indicated that available soil moisture from rain was the primary factor influencing seedling establishment. The time required for emergence of alfalfa was less than half that required for the clover. Under favorable conditions (the April 22 date) both species were equally well established in 8 days but at the less favorable planting dates (May 23 and July 10) equal emergence was not obtained until 3 weeks after seeding.

From seeding dates in April and early May, excellent emergence was obtained but from seedings made in the late spring or summer poor stands were obtained. Cool moist soils following the September 4 seeding resulted in a high emergence of both species but it is uncertain whether such small seedlings will survive the winter.

The importance of various climatic factors on seedling establishment and particularly soil moisture relationships was evident. It was apparent that the early rate of growth of specific seeds may determine the stand, and especially when precipitation is not abundant.

Phosphate Solubility, Placement and Temperature in Relation to the Growth of Red Clover

Studies concerning the interaction of temperature and phosphate placement (1956 Annual Report, page 20-21) were continued. However, in these studies another factor, phosphate solubility was introduced.

Four rates of 5, 25, 50, and 100 percent water soluble phosphate were added to Morrison loam in 4-inch glazed pots. In half of the pots the various levels of water soluble phosphates were added to the soil in narrow bands 1 inch below the soil surface at rates equivalent to 0, 25, 50, and 100 pounds of P_2O_5 per acre. In the other half of the pots the phosphorus was mixed with the top 2-1/2 inches of soil at rates equivalent to 0, 50, 100 and 200 pounds of P_2O_5 per acre at the different solubilities. Red clover was seeded in the pots and later thinned to five plants per pot. Three replications of each treatment were seeded. The pots were then placed in controlled temperature chambers at 50°, 60°, 70°, and 80° for a period of 6-8 weeks.

The most dry matter from red clover was obtained at 60° F. regardless of whether the phosphates were banded or mixed in the soil. The next best growth was obtained at 70° F. and least dry matter was produced at 50° F.

The importance of banding and water solubility is most pronounced at the lower temperatures and decreases with an increase in temperature. However, at all temperatures and when the phosphorus was banded, yields increased with an increase in water solubility. For instance, at 60° F. with an application equivalent to 100 pounds of P_2O_5 per acre, the yield from the 50 percent water soluble phosphorus was approximately twice that of the 5 percent water soluble phosphorus, and using 100 percent water soluble P_2O_5 , it was three times greater. Water solubility was of greater importance when the fertilizer was placed in a band than when mixed with the soil.

When phosphorus was mixed with the soil the 5 percent and 25 percent water soluble phosphorus resulted in slightly greater yields than from the more water soluble phosphorus. It appears that the less water soluble phosphorus (5 and 25 percent) is equally effective whether banded or mixed with the soil. However, the highly water soluble material is much more effective when banded, and especially at the lower temperatures.

These results suggest that in this experiment a highly water-soluble phosphate fertilizer may be no more effective than a phosphate fertilizer that is only 5 to 25 percent water soluble when it is disked into the soil.

Further studies will be conducted to determine whether the response of red clover to temperature and phosphorus is due mainly to the effect of temperature on the soil or on the physiology of the plant. Red clover will be grown in culture solutions at low, intermediate and high levels of phosphorus to determine whether similar responses are obtained as when red clover is grown in soil.

RESEARCH AT BELTSVILLE, MARYLAND

Title: CLOVER RESEARCH

Leader: E. A. Hollowell

Healthy and virus-infected clonal plants of Ladino white clover were compared for seed production. In the greenhouse test, virus infection reduced flowering in plants in one clone 31.7 percent. In field plots, virus infection reduced flowering in plants of two clones 20.3 and 43.9 percent, respectively. Seed yield from virus-infected plants of both clones was reduced 29.2 and 53.7 percent, respectively. There was no difference in viability of seed harvested from virus-infected and healthy plants, nor was there any difference in percentage of abnormal seed. The virus infection was not transmitted through seeds.

To facilitate screening white clover for resistance to virus diseases a study was made to determine at what stage of development seedlings could be artificially infected most readily with viruses commonly isolated from white clover. Young white clover seedlings were inoculated in cotyledonary, simple, and first trifoliolate leaf stages with a strain of alfalfa mosaic virus and one of bean yellow mosaic virus, either alone or in combination. Seedlings could be infected readily with bean yellow mosaic virus regardless of stage of development. In contrast, seedlings inoculated with alfalfa mosaic virus were more difficult to infect at the stages tested. As a result of this study a method was developed whereby seedlings can be inoculated, observed for virus symptoms, and tested for presence or absence of virus infection within approximately 4 to 6 weeks after the seed is sown.

Chemical tests for determination of virus infection in Ladino white clover were conducted. The arginine test, 2, 3, 5-triphenyl tetrazolium chloride, and six other redox agents were used as possible indicators of virus activity. Temperature at which tests are conducted, virus titer, pH, buffers, tissue, light and other factors need to be studied more critically before usefulness of methods can be determined.

During 1956, over 5,000 individual white clover plants representing more than 225 seed lots of different world-wide varieties and seed sources were artificially inoculated with alfalfa and bean yellow viruses in the greenhouse. Percentage infection ranged from 0 to 41. percent. Symptomless plants were transplanted to field nursery. By the fall of 1957 all but 30 plants had become infected. These plants are being cross inoculated to determine if they are resistant or are symptomless carriers.

Mode of fertility was determined on 63 (Trifolium spp.) lots, most of which were different species of limited seed supply, obtained through the New Crops Research Branch.

Florets of 2 to 10 plants of each lot were selfed while others were outcrossed to other plants of the same lot. Species are being identified at the present time. Twenty-four lots proved to be self-sterile. Considerable variability in percent seed set, existed between outcrossed plants of the same lot and species.

Title: GRASS RESEARCH

Leader: A. A. Hanson

The studies reported in the 20th Annual Report of Pasture Research in the Northeastern United States are being continued. Some preliminary work was conducted in attempting to induce male-sterility. Chlorinated butyric acid has been used with fair success to induce male-sterility in cotton. Plants of tall fescue, ryegrass, Kentucky bluegrass, and Zoysia japonica were sprayed with 0.2, 0.5, 1.0, and 3.0 percent solutions of sodium alpha, beta-dichloroisobutyrate. The 3.0 percent concentration damaged the plants, but none of them was completely killed. Plants have been treated at various stages of development from completely vegetative to heading. The preliminary results have been erratic. We will continue to treat plants and check pollen viability to see if this chemical offers any promise in the production of hybrid varieties.

Title: BIRDSFOOT TREFOIL BREEDING

Leaders: P. R. Henson, K. W. Kreitlow, J. F. Fulkerson and N. G. Brandenburg

Stands of birdsfoot trefoil, particularly on the lighter soils in this area, thin out at beginning of the second summer due to various crown and root rotting organisms. The situation is so serious that the breeding program to develop greater seedling vigor had to be amended to include breeding for disease resistance. Severe killing occurred during the second summer (1955) in the first disease nursery and only 3% of the plants were saved for further study. A second disease nursery made up of the above 3 percent plus selected plants from introductions, varieties and strains, was established in 1956. Killing during the summer of 1957 was again severe and tolerant or resistant plants have been saved for further study. A number of the plants saved from the first disease nursery came through the second test in good condition. Organisms have been isolated from diseased plants and greenhouse studies are being conducted to determine which organisms or group of organisms are responsible for the killing.

Effects of inbreeding in birdsfoot trefoil are being studied. S_1 lines were less vigorous and lower in self-fertility than their parents. Two S_1 lines in comparison with their parents were lower in pod set, number of seeds per pod, seed size and percent of plump seed.

Title: BIRDSFOOT TREFOIL BREEDING AND GENETICS (at Ithaca, N.Y. in cooperation with N.Y.)

Leaders: P. R. Henson, R. R. Seaney, and D. Gershon

New introductions of L. corniculatus and L. uliginosus have been evaluated for performance in space-planted nurseries. In order to preserve their genetic identity, indigenous strains of L. corniculatus and L. tenuis have been collected from areas in eastern New York.

Studies are in progress to develop lines of L. corniculatus which have some degree of resistance to seed shattering. Methods of selection and interspecific hybridization are being used for this purpose. Several species with chromosome numbers of $2n = 12$ have been found to be indehiscent or to have resistance to shattering.

Chromosome numbers have been determined for 50 different species of Lotus. Chromosome numbers and morphological characteristics indicate a close relationship between L. angustissimus, L. corniculatus, L. divaricatus, L. filicaulis, L. hispidus, L. japonicus, L. lamprocarpus, L. parviflorus, L. tenuis, and L. uliginosus.

Genetic studies are in progress on the inheritance of cyanogenesis in L. tenuis and L. corniculatus, and seed coat color in L. angustissimus. Two classes of cyanogenic plants have been noted in L. tenuis. One class has a very positive hydrogen cyanide reaction and the other a very slight reaction.

The self-fertility of plants of Viking appears to be different for field and greenhouse pollinations. Plants which are self-sterile in the greenhouse, set seed when self-pollinated in the field. Pod and seed set were compared for two methods of self-pollination. These methods were "tripping and rubbing", in which the stigma was extruded and lightly touched against a wooden toothpick, and "pinching or rolling", where the flower cluster was simply rolled between the fingers. The latter method is much faster and was equally effective as the former in producing seed, as shown in the following table.

<u>Method of Pollination</u>	<u>Number of Flowers Pollinated</u>	<u>Number of Pods Set</u>	<u>Number of Seed Set</u>	<u>Seed per Flower</u>
Tripping	7217	551	3497	.49
Rolling	5258	398	2615	.50

On the basis of germination tests, seed of L. uliginosus was found to be more susceptible to damage by x-ray and thermal neutron irradiation than seed of L. corniculatus. Stimulation of seedling growth was noted when L. corniculatus seed was treated with 50,000 r of x-ray irradiation.

Title: FOUNDATION SEED PRODUCTION OF GRASS AND LEGUME VARIETIES

Leader: C. S. Garrison

The rapid build up in certified seed of improved forage crop varieties is dependent upon an adequate supply of foundation seed. The work of the Foundation Seed Project is directed towards this end and is carried on in cooperation with the seed trade, the seed certifying agencies, foundation seed organizations, and 38 state experiment stations and extension services. The following varieties are included in the Project: Atlantic, Buffalo, Narragansett, Ranger and Vernal alfalfas; Dollard, Kenland and Pennscott red clovers; Potomac orchardgrass; Starr millet; Empire birdsfoot trefoil; and Gahi #1 pearl millet. The latter was included by the Advisory Committee (Planning Conference) in December 1957.

Foundation seed of all varieties was adequate to meet planting needs in 1958 except for Narragansett alfalfa and Dollard red clover. To meet the need for planting stock of Narragansett alfalfa the appropriate Northeastern Forage Crops Technical Committees reinstated the registered seed class. The acreage producing foundation Dollard red clover has been greatly expanded and supplies should be plentiful after harvest this year. The production of foundation seed of varieties in the Project during 1957 amounted to over 460 thousand pounds.

Title: INVESTIGATIONS OF GENETIC STABILITY IN SEED OF IMPROVED FORAGE
CROP VARIETIES

Leader: C. S. Garrison

Limited investigations were initiated in 1957 to study the genetic stability of seed of forage crop varieties established vegetatively and grown in different areas for one or more generations. These studies involve the production of seed from 15 vegetatively propagated synthetic combinations representing seven species, namely, alfalfa, red clover, white clover, birdsfoot trefoil, orchardgrass, brome grass and timothy, from eight Eastern, Southern and North Central experiment stations. In most instances the synthetic combinations were constituted from clones with specific morphological, physiological and pathological characteristics. The synthetic combinations from the Northeastern Region consist of: New Hampshire white clover (5 clones); a Pasture Laboratory white clover (6 clones); Saratoga brome grass (5 clones); Essex timothy (4 clones); Pennlate orchardgrass (4 clones); a Beltsville orchardgrass (4 clones); Pennsylvania birdsfoot trefoils (7-clone and 6-clone); and Beltsville birdsfoot trefoil (4 clones).

Experimental seed production areas have been established at Prosser, Washington - 46 degrees latitude, 700 feet elevation; Logan, Utah - 41 degrees latitude, 4,200 feet elevation; Shafter, California - 35 degrees latitude, 365 feet elevation; Tehachapi, California - 35 degrees latitude, 3,600 feet elevation; and College Station, Texas - 31 degrees latitude, 350 feet elevation. Seed of each synthetic will be harvested and advanced from one to three additional generations in different environments. During the three years that seed will be harvested from the vegetatively propagated plants special studies will be made of the performance of the individual clones in each of the synthetic combinations.

Comparisons were made between 21 lots of certified Ranger alfalfa, including breeder and foundation seed, and 163 lots of non-certified Ranger. Each lot was evaluated for fall growth habit and bacterial wilt resistance. Two of the certified Ranger lots (10%) were questionable - 1 each for fall growth habit and bacterial wilt infection. In the group of non-certified Ranger lots 90 or 55.2% did not meet the minimum standards established by statistical analysis for genetic purity for the two factors - fall growth habit and bacterial wilt.

REPORTS OF R. AND M. COOPERATIVE RESEARCH

Title: PROJECT NE-13 - THE MECHANIZATION OF FORAGE CROP HARVESTING, PROCESSING, STORING AND FEEDING

Leader: W. C. Wheeler, Chairman, Regional Technical Committee

Cooperators: Storrs (Connecticut), Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations, and the A.R.S., U.S.D.A., Agricultural Engineering Research Division, Beltsville, Maryland

Drought conditions in some areas of the Northeast are reflected in reports from the contributing state projects. The combined mechanization accomplishments in the areas of Harvesting, Processing, Storing and Feeding of forage crops in the Northeast are summarized as follows:

(1) Harvesting. Power requirements for field cutting of forage crops were limited to thin stands of alfalfa at Connecticut. New strain links were used and the entire cutter bar has been instrumented for both laboratory and field testing. Preliminary tests have been run on the effect of shape of cut on the recovery rate of grasses.

A torsion dynamometer was developed at West Virginia and used to determine the power requirements for flail and rotary forage harvesters. Additional studies on the flail forage harvester at West Virginia and Massachusetts include drying rates and other aspects of use.

Hay conditioners under test gave consistently faster drying of hay with no major operating difficulties. West Virginia used various pressures on hay conditioners. Fluffing (simulated tedding) failed to decrease drying time appreciably at West Virginia and Pennsylvania. Two types of machines were studied at Maine, New Jersey, Pennsylvania and West Virginia while the work at Massachusetts was confined to the crimper only.

Tests on a field bale loading elevator and tractor buck-rake were continued at Maine. A comparison by AERD, ARS for "Direct cut" vs. "Wilted" methods of harvesting grass silage shows the production of more dry matter per hour of forage harvester operation when the wilting method is used.

Tests at Massachusetts with low pressure (12 psi) tires vs. standard (60 psi) tires for various loads on test plots failed to result in the great differences in forage yield that have been reported in the past. Tests to date would indicate that floated equipment on low pressure tires is of primary advantage during wet seasons.

(2) Processing. The batch drier for baled hay gave another year of satisfactory performance at West Virginia. Cost of operation was approximately \$4.50 per ton. Pennsylvania found that the size of bale had little effect on its drying rate; however, the less dense bales dried faster. The most favorable results with an oil-fired continuous bale drier at West Virginia were obtained with 40% moisture hay and no more than 1200 pounds of force used to move the hay through the drier. The drier would not perform satisfactorily with soybeans or 50% moisture content hay. Redesign of the unit for better control of air and heat losses and recirculation of air is underway.

Drying of bale slices improved the performance of the wagon drier. Handling baled hay in slices offers the opportunity of eliminating hand labor associated with baled hay harvesting. A new four-way drying unit is under study.

Several mathematical formulas have been determined to express the characteristics of the batch drying process of chopped alfalfa at New Jersey.

A 3-tier air duct system dried 50 tons of 32.6% moisture chopped hay at Pennsylvania and used approximately 30 KWHr. per ton. The mow was 20 feet wide with a hay depth of 19 feet.

Work by the AERD, ARS on ensiling and preservation of high moisture silage indicates the following: 1) The addition of beet pulp improved the quality and increased the dry matter consumption of high moisture silage; 2) Recirculation of seepage appears to be of no benefit in preserving silage quality; 3) No difference in quality or feeding value was found between chopped and unchopped silage preserved in bunker silos; 4) Detail small-scale studies indicate consolidated silages in unsealed silos were generally of poor quality but were of good quality when the silo was sealed; 5) The lowest rates of nutrient preservation were with non-compacted silages made in unsealed silos; 6) Early stage of maturity orchardgrass had considerably greater density than when cut one week later; 7) Densities of other grasses have also been determined.

(3) Storing. Distribution systems for placing partially cured chopped hay in mows at Pennsylvania and New York have been improved. Roller chains with flights and multiple chains seem to offer more promise than belts for this application. The diameter of the belt-tube elevator, developed by New York, has been increased to 10 inches. Entrance plugging has been reduced. Chopped hay can be elevated at an angle of 80°. A wider belt or an added top belt will be needed before the elevator will handle silage.

A new simplified forage distributor used in the tower silo at New Jersey was tested and proved to be satisfactory. The distribution pattern was uniform and vibration was reduced.

Investigation continued at Maryland on the pneumatic handling of chopped alfalfa. Equipment has been instrumented to determine the power used. A duel belt conveyer has replaced the forage blower for introducing material into the air stream. Material in the air stream increased the friction loss in the 9-1/4" and 14" pipe.

Silage unloading metering devices and commercial unloader power units continue to be studied at Maine. Tests with a belt-type silage impeller have been discontinued.

Bunker silo covers made of plastics reduce spoilage loss but require some type of weighting for protection (AERD, ARS).

(4) Feeding. The pole barn and horizontal silo at West Virginia performed satisfactorily for a second year. Thirty-one Hereford cows were housed and fed. A 50 ft. long by 9 ft. in. diameter screw conveyer is being used at another farm to service a hay and silage bunker.

Improvements continue to be made in the performance of the self-feeder tower silo in New Jersey. The best results were obtained with a 16 ft. diameter silo 48 ft. tall. It required 17 man-hours to feed 213 tons of soybeans and sorghum silage to 100 Hereford steers.

An experimental silo unloader is under study at West Virginia. Vermont added a second drive wheel to their silo unloader which improved its performance.

Improvements have been made in the manger conveyer portion of the feeding system used at Vermont and it is now considered satisfactory. Work continues on improving the flow of high molasses content ground feed from bulk bins.

The Vermont grain metering device, based on metering by weight, has been developed to a satisfactory point and a publication is being prepared.

The use of newly developed forage handling methods and equipment has enabled double cropping practices to be used on a small experimental farm in New Jersey. The animal carrying capacity of the farm was doubled by introducing the practice and the method.

USEFULNESS OF FINDINGS:

The field drying time for hay can be significantly reduced by the use of hay conditioners. Low pressure tires for harvesting equipment permit more timely operations under adverse field conditions. Flat belt type of conveyers have not proved to be suitable for handling high moisture forages. The belt-tube principle of elevating high moisture chopped hay makes possible near vertical operation with sufficiently high capacity to fit any existing handling systems. Chain type elevators and conveyers offer an economical means for handling forage. Conveyer feeding systems offer means of reducing labor in stanchion type dairy barns. A grain metering device, based on metering by weight, offers means of better control over quantities fed. The PTO torsion dynamometer has numerous possible applications with agricultural machines and in industry.

Two machinery manufacturers have shown intense interest in the tests conducted to determine the energy requirement for cutting forage. Flail forage harvesters have lower power requirements than rotary forage harvesters. The self-feeder silo is presently being tested commercially. Wagon drying of hay provides a convenient and acceptable method of drying hay on intermediate size farms. The effectiveness of small farms can be increased by the introduction of new farm practices and methods.

WORK PLANNED FOR NEXT YEAR:

The project is due to be revised in mid-year. A committee was appointed to evaluate the accomplishments so far and make recommendations. The reports by the committee members indicate quite conclusively that the objectives of the project have not been completed and that further study is needed in all areas with major emphasis on work of a fundamental nature. Some projects have been closed and other projects will be initiated.

Work that will be carried on during the next year under existing projects includes: Effect of compaction on yield and maintenance will be continued by Massachusetts. Maine, Massachusetts, and West Virginia will continue studies of hay conditioners. Energy requirements for cutting forage crops will receive further study at Connecticut. Studies will also be made at Connecticut on the shape of cut and the relationship of knife speed to machine travel speed. Bale handling studies will continue at Maine.

Crop drying studies will continue at West Virginia, New Jersey, and Pennsylvania and various aspects of silage making, handling and preservation will continue under study by AERD, ARS.

Work with blowers, conveyers, elevators and unloading devices to reduce labor in moving forage crops into storage will be continued. Bulk grain bins continue to be studied at Vermont.

Silo unloader studies will continue at West Virginia. Vermont will continue studies in integrating a silo unloader and metering silage to the conveyer feeding system. Work on self-feeder structures will continue at New Jersey.

New York will initiate laboratory studies on devices for the formation of hay cakes and/or pellets.

Title: PROJECT NE-18 - ECONOMICS OF FORAGE PRODUCTION AND UTILIZATION

Leader: Niels Rorholm, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Delaware, Maine, Massachusetts, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations

The regional project has 4 objectives as follows: (1) To examine and describe the present patterns of production, harvesting and utilization of forage crops in different land areas. (2) To analyze the physical and economic input-output relationships of forage production. (3) To analyze the physical and economic input-output relationships of forage utilization. (4) To analyze the economic effect of alternative combinations of forage production and utilization on farm businesses with different resources and with different market outlets.

Work under objective 1 has centered around a final analysis of the descriptive data and publication of results by individual states as well as through a regional publication.

In the main, the analytical work of the year has centered around objectives 2, 3, and 4.

In New York, New Jersey and West Virginia the survey method has been used to gather farm business information on the forage part of farm operations. In New York some analysis has been made from 556 commercial dairy farms of the relation of plant food inputs to crop yields and of roughage and grain feeding to milk production. In West Virginia, it was found that a farmer's status with respect to age of and off-farm work had no effect on the choice of crops. Farmers average 4.3 pasture fields per farm, the majority of which were native unimproved pasture. Budgeting analysis indicated that on the average forage production could be increased by 27% with a change in crop selection and that if yields were increased modestly and 50% of the pasture improved, forage production could be increased by approximately 80%. The farm business information in New Jersey on 83 farms will be used to point out characteristics of profitable forage systems.

An economic evaluation of pasture improvement and renovation is being made using data from dairy farms in Northeast Pennsylvania, experimental plots in the area, custom work charges for specified clearing operations and data from other studies. Using the above information representative farm situations are being synthesized to form the basis for linear programming estimates of the economically most desirable combinations of renovation practices on (1) land that includes little or no rocks, (2) land with over 50% coverage with briars, brush or rocks, and (3) land with over 50% coverage of brush and trees. Improved permanent pasture vectors are also included in the linear programming model.

In studying the effect of soil types on forage production researchers at Vermont did not find any great effect of the soil type on forage yield. Apparently other factors, such as management practices and fertilizer applications, had more important effects obscuring the effect of soil differences.

Input-output data for grass silage operations have been gathered on 25 Massachusetts dairy farms. Major attention has been given to the combination of labor and machinery. In addition, analysis of "green pasture" farms is being continued.

In Rhode Island 96 budgets are being used to study the effect on farm profits of adopting soilage practices. Tentative analysis shows that soilage feeding is a type of development which could profitably be adopted by the farmer who has already achieved reasonably good efficiencies in his general dairy operations. It does not seem likely, however, that soilage feeding will increase profits for the average or below average dairy farmer.

Maine published the bulletin 561 "Costs of Forage Production and Utilization on Several Maine Dairy Farms" by H. B. Metzger. Cost estimates for various types of forage were as follows for all operations, that is, producing, harvesting, storing and removing from storage: \$24 per ton for hay, \$34 per ton for grass silage, and \$32 per ton for corn silage on a hay equivalent basis.

Based on data from Delaware farm records, budgets are being worked out on improvement of forage crop operations and these budgets are being tested in cooperation with farmers. Budgets involve changes in rotations as well as in herd size. In addition, farmers and the Agricultural Chemistry Department are cooperating in attempting the derivation of a more desirable measure of forage quality.

At Connecticut, experimental results have been used to derive production functions for major forage crops relating the output of forage to fertilizer inputs. An exponential function of the type $Y = aX^b$ was used. The most economic method of increasing the supply of forage will, of course, depend on prices, but the following general guides have been established:

1. Use of more than 3.3 acres of cropland per animal unit to meet forage needs is uneconomic due to overhead costs of land. More intensive use is less costly than extensive use.
2. If the cropland acres per animal unit is between 1.6 and 3.3, forage needs can be met at least cost through careful selection of crops, crop rotation, and fertilizer applications.
3. If the cropland acres per animal unit is less than 1.6 acres, alternatives of increased fertilization, land renovation, land rental, land purchase, or hay purchase should receive careful attention. Anytime that the cost of one method of procurement is below the cost given on the formula above, that alternative is more economic than intensification of fertilization.

USEFULNESS OF FINDINGS:

In spite of apparent differences in the state projects contributing to NE-18, the projects address themselves to the problem of how to operate the forage program in such a way as to secure maximum profits to the farmer. In the Northeast region with its heavy emphasis on dairy production and generally high forage prices, economic success in forage production and utilization is an absolute necessity. The results of this project will, when applied, do much to insure such success.

WORK PLANNED FOR NEXT YEAR:

Data will be analyzed and published. A revised regional project will be submitted dealing with further needed research in the field of economics of forage production and utilization on dairy farms.

Title: PROJECT NE-24 - THE NUTRITIVE EVALUATION OF FORAGES

Leader: C. R. Richards, Chairman, Regional Technical Committee

Cooperators: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, West Virginia and Vermont Agricultural Experiment Stations, the U. S. Regional Pasture Research Laboratory, the Dairy Husbandry Research Branch and the State Experiment Stations Division, A.R.S., U.S.D.A.

The objectives of the project are: (1) To evaluate various forages grown under known conditions and harvested at specific stages of maturity by determining digestible protein and digestible energy; and to measure the annual harvest of nutritive value by taking into account both acreage yield and nutritive value per unit of dry matter. (The determination of digestible dry matter may be substituted for digestible energy in grazing experiments). (2) To develop methods for the nutritive evaluation of forages; these to include the use of small animals and chemical analysis. (3) To conduct animal production trials simultaneously insofar as possible.

The following State Experiment Stations have contributing projects to this regional project: Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia. The United States Regional Pasture Research Laboratory also has work of a related nature, as does the Dairy Cattle Research Branch.

First cutting alfalfa harvested at different stages of maturity is under study in digestion trials at the Delaware, Maryland, Pennsylvania, Rhode Island and Vermont Stations.

Other forages being evaluated by digestion studies include: red clover (Rhode Island), alfalfa-brome mixture (Delaware), brome grass (New Hampshire, Pennsylvania and New Jersey), reed canarygrass (New Jersey and Maine), timothy (Maine), alfalfa-light grass mixture and mixed grass (Massachusetts). Several mixtures are being studied at the New York Station. Present results show a decrease in digestibility with increasing maturity. Data from the New York Station are in agreement with those previously obtained, which suggest that the digestibility of energy from first growth forages may be predicted from the harvest date.

Digestion studies are underway with cattle at New Hampshire, Massachusetts, and Maryland and comparative studies are being conducted with sheep at Pennsylvania on samples of the same forages. Results continue to indicate excellent agreement between these species. Similar results have been obtained with comparative studies at the New Jersey Station. The comparative digestibility of alfalfa and an alfalfa-brome mixture by sheep and rabbits is under study at Delaware. Results with alfalfa indicate that digestible protein was similar for sheep and rabbits, while digestible energy and digestible dry matter were about 25% and 15-20% lower, respectively, with rabbits than with sheep.

The effect of varying levels of nitrogen fertilization on the feeding value of grasses is under investigation at the New Jersey, Maine, New Hampshire, and New York Stations. Results from New Jersey indicate that crude protein and apparent digestibility of protein and energy were increased in brome grass fertilized with 25, 125, and 225 lbs. of nitrogen per acre.

The effect of level of forage intake on digestibility is being studied at the New York Station. Little or no influence on digestibility was observed from this variable. The effect of irrigation and weathering on the digestibility of forages is also being studied at New York.

Lactation and digestion studies are in progress at Massachusetts in which two forage mixtures: (1) predominantly alfalfa and (2) predominantly grass, are being compared. There appears to be little difference between the two hays in regard to efficiency of milk production or digestibility of dry matter and energy. Lactation experiments were also conducted at Maryland utilizing first cutting alfalfa harvested at one-tenth bud, full bud, and full bloom, as the sole feed. At Maryland, milk production efficiency followed the same trend as previously noted, with decreasing efficiency accompanying increasing maturity. The Vermont Station is in the process of comparing the value, for lactation, of an alfalfa-brome grass mixture harvested at the full bud and at an early seed stage of maturity. Pure stands of forage will be established in 1958 for study as outlined.

The West Virginia Station is studying the feasibility of obtaining digestion information on forages by in vitro methods which involve digestion of the plant material by rumen fluid. Preliminary results indicate good reproducibility of the results with this technique. In an associated project, the U. S. Department of Agriculture Regional Pasture Research Laboratory is investigating techniques for the chemical evaluation of the feeding value of forages. Fractionation of grasses into ether-soluble and alcohol-soluble and alcohol-insoluble fractions, and comparison with digestion data, has resulted in the development of the following formula for estimating digestible organic matter. This applies to grasses only:

$$0.4 (EE) + 1.0 (AS) + (0.01) (104.4 - 4.34 X) (AI)$$

where EE is ether-soluble, AS is alcohol-soluble and AI is alcohol-insoluble, all in percent of total organic matter, and X is lignin in percent of alcohol-insoluble.

USEFULNESS OF FINDINGS:

The results of these and future studies will aid in making recommendations to farmers of the comparative nutritive value of the various species and varieties of forage best to grow in utilizing the potential forage production of their farms. They will also add to the evidence on nutritive value of forage grown under different production and management practices.

A more critical evaluation will be available on the digestible energy value of forages determined with different species of animals. Evidence in the literature does not firmly establish the applicability of values where determined with different species.

In the New York area, the finding that the energy value of first growth forage (in terms of digestible dry matter) is closely related to the date of cutting, has been adapted for use in practical feeding. This allows farmers to determine more accurately how much concentrates to feed, and based on measure of total crude protein of forage, to predict the percentage of protein needed in concentrates.

WORK PLANNED FOR NEXT YEAR:

The work will continue along the lines presently outlined. The data from comparative digestion studies between Pennsylvania, New Hampshire, Massachusetts, and Maryland will be summarized. Some stations will introduce new forage species into their studies. Work on nitrogen fertilization will be expanded at several stations.

Title: PROJECT NE-28 - BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO THE NORTHEAST

Leader: C. C. Lowe, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Maine, Maryland, New Hampshire, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations, The U. S. Regional Pasture Research Laboratory, the Crops Research Division, the State Experiment Station Division, A.R.S., U.S.D.A., and the American Seed Trade Association

The state experiment stations which cooperated in the tests in 1957 are: Orchardgrass - New York, Pennsylvania, Maryland; smooth brome grass - New Hampshire, New York, Pennsylvania; timothy - New York; alfalfa - Maine, Connecticut, Rhode Island, New York, Pennsylvania, New Jersey, West Virginia; birdsfoot trefoil - Vermont, New York, Pennsylvania; Ladino clover - New Hampshire, Maryland.

Regional adaptation and performance of the best available breeding materials in the Northeast for orchardgrass, brome grass, alfalfa, birdsfoot trefoil, Ladino clover and timothy are being evaluated under this project. Selected clones of each species are being tested on the basis of clonal and progeny performance. Experimental synthetic varieties constituted by intercrossing the superior parental clones are being produced and tested against other experimental varieties and commercial varieties now in use. Selection is being based on the morphological and physiological characteristics appropriate for improving both the quality and quantity of forage for each species.

Species are in different stages of advancement for regional evaluation of the available breeding material.

Orchardgrass. Three years of testing are complete on the selected clones and their progenies. Seed of five experimental synthetics constituted on the basis of trial information is now available for testing. Results to date are promising for the production of late-maturing varieties which will improve forage quality and make this species easier to manage while retaining the high yielding ability of early maturing strains. Within the earlier type orchardgrass, there appears to be little chance of improving actual yielding ability over Common orchardgrass with the current breeding materials. However, several of the experimental varieties tested have shown greater leafiness and disease resistance; these characters are indicative of better quality.

Bromegrass. Clone and progeny tests have received three years of evaluation. Seed has been produced for three new synthetics compounded on the basis of superior regional performance by their parental clones. Criterion of selection in #1, was overall merit; in #2, creeping growth habit; and #3, bunch growth habit. Varieties specific for these characters could increase the use of bromegrass. Of the synthetics tested, New York Syn. B (Saratoga) has been superior in aftermath production. New York Syn. H and Syn. L and several of the U.S.D.A. synthetics have also been outstanding over check plots of the currently used commercial strains. In this species, both total season and aftermath production have been improved in the experimental synthetics over current varieties. Chances are good for further improvement with the materials being tested.

Birdsfoot Trefoil. The tests on birdsfoot trefoil clones and progenies indicate little promise for the current breeding material other than as possible source material for further selection. Two of the synthetic varieties tested have given performance about equal with Viking, the highest yielding check variety. Evaluation will be continued on these.

Alfalfa. Yield information is now being obtained from synthetic and polycross progeny tests at six locations and additional tests were established in 1957. Several years of testing are a minimum requisite but the current trials should result in the synthesis of varieties with regional adaptation. Several experimental synthetics show promise on the basis of the first year results. Appreciable information was obtained from the clonal nurseries in 1957.

Ladino Clover. Work has recently been initiated on this species. Polycross progeny tests were established at three locations and variety and synthetic trials at six locations during 1957.

Timothy. Polycross progeny seed of 85 clones was produced in 1957 and will be available for testing in 1958.

Stations in the Eastern part of the region suffered the most critical drought conditions in several decades. Yields were reduced to a small fraction of what may be considered normal. This has contributed to appreciable variation in variety or progeny response between stations and between seasons. A number of locations and tests within locations are necessary to be sure of adequately ascertaining regional adaptation.

USEFULNESS OF FINDINGS:

The degree of superiority and range of adaptation for recently released varieties of bromegrass, orchardgrass and birdsfoot trefoil has been more clearly established by the results obtained on trials for varieties and synthetics of these species.

Clonal and progeny performance have indicated considerable promise for some of the selected clones of late orchardgrass, brome grass and alfalfa being tested to be combined into synthetic varieties of value to the Northeast region. Information to date indicates that the current breeding material for early orchardgrass and birdsfoot trefoil holds little promise and that further selection for parental clones will be needed.

WORK PLANNED FOR NEXT YEAR:

The current tests on alfalfa, birdsfoot trefoil and Ladino clover will be continued. New tests will be established to evaluate the experimental synthetic varieties of brome grass and orchardgrass which have been produced on the basis of test results from this project. Progeny tests for selected timothy clones will be planted. Seed production blocks for experimental synthetics of orchardgrass, brome grass, and birdsfoot trefoil will be established, based on the specific performance of parental clones at individual locations within the region.

The completed research results of the project from 1955 through 1958 will be summarized and prepared for publication.

Title: PROJECT NE-29 - ESTABLISHMENT AND MANAGEMENT OF PERENNIAL FORAGE SPECIES AND VARIETIES FOR PERSISTENT PRODUCTION IN THE NORTHEAST.
 SUB-PROJECT I - SEEDLING ESTABLISHMENT AND EARLY DEVELOPMENT OF FORAGE GRASSES AND LEGUMES AS AFFECTED BY CULTURAL TREATMENT.
 SUB-PROJECT II - PERSISTENCE, PRODUCTIVITY AND GROSS NUTRIENT VALUE OF PERENNIAL FORAGE CROPS AS INFLUENCED BY MANAGEMENT PRACTICES.

Leader: John B. Washko, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Maryland, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations, the U. S. Regional Pasture Research Laboratory, The Crops Research Division, the Agricultural Engineering Research Division, and the State Experiment Station Division, A.R.S., U.S.D.A.

This regional research project was initiated July 1, 1954, as Phase I and II of Regional Research Project NE-21. It was reorganized July 1, 1955 as Regional Research Project NE-29.

The primary objectives of this study are to determine (1) the effect of various methods of seeding and of fertilizer application and placement on the establishment and early development of forage crop seedings; (2) the effect of different cropping and clipping practices for plant competition control, on establishment, early development and winter survival of forage grasses and legumes when seeded with and without a companion crop; (3) the interrelationship of species, cultural methods, management systems and climatic factors as they influence seeding establishment; (4) the influence of seeding methods and management practices on the eventual yield, composition and persistence of forage crop seedings; (5) to develop techniques and practices which will result in more effective, reliable and economical forage crop establishment and production, and (6) report monthly the microclimatic factors of air temperature, humidity, radiation, soil moisture and temperature as they influence all seeded experiments.

Sub-project I - Seedling Establishment. Investigations on seedling establishment are being carried out at 6 Experiment Stations, namely, Connecticut, Maryland, New Jersey, New York, Pennsylvania and Vermont. The seeding of these experiments was accomplished primarily with the aid and fine cooperation of the Agricultural Engineering Research Division, Agricultural Research Service, U.S.D.A. which provided specialized seeding equipment.

At the first 5 of the stations listed, experiments were conducted from 1954-1957 comparing band and broadcast placement of seed and fertilizer. Phosphorus and potassium ratios and amounts were also incorporated into these experiments, constituting the first phase of the investigations. At most stations, band seeding gave quicker emergence and more rapid seedling development. However, these did not necessarily result in higher forage production the year following establishment. In fact, at four locations, Connecticut, Maryland, New Jersey and Pennsylvania in 1957 band seedings were not superior to broadcast seedings when measured in terms of forage yields with an alfalfa-bromegrass association. Nor did this forage mixture show a decided response to either ratios or amounts of P and K within the region except at Connecticut where a response to P was obtained with band seeding. Moreover at Connecticut and New York, better bromegrass stands were obtained with band seeding than with broadcast seedings. Apparently the results obtained with band seeding are related to local soil conditions, particularly, basic field fertility level. When this fertility level is low, band placement of both seed and fertilizer is reflected not only in better stands of forage species but higher forage yields.

In a second phase of the work on seeding establishment, experiments were seeded at all six stations listed in 1957 involving; (1) the use of an oat companion crop vs. none, (2) three legume-grass mixtures, alfalfa-brome, Ladino clover-orchardgrass, and birdsfoot trefoil-timothy, and (3) differential clipping and removal of both the oat companion crop and weed growth to minimize competition.

Successful stand establishment of the various forage species was drastically limited by the severe drought which prevailed in all locations where experiments were seeded except Vermont. However, the drought emphasized the importance of several management factors and species characteristics important in stand establishment: (1) a companion crop offers severe competition to young seedlings particularly in times of moisture stress since poorer stands of forage seedlings were obtained with the oat companion crop than without; (2) the attrition in stands of forage species during drought is severe as indicated by stand counts made in June and again in August; (3) generally frequent clipping of seedlings made alone to minimize weed competition tended to favor seedling establishment; (4) complete removal of weeds by hand weeding resulted in the establishment of highly successful forage stands of alfalfa-bromegrass and Ladino clover-orchardgrass associations; severe clipping of weeds as a management practice failed to match weed removal by hand in the promotion of successful forage stands; this again emphasizes the serious nature of weed competition in forage crop establishment; (5) in general, better stands of legumes were obtained than with the grasses; (6) alfalfa and birdsfoot trefoil because of their greater drought tolerance became better established than Ladino clover; and (7) poorest establishment of the grasses was obtained with timothy.

Yield data taken during 1957 from these second phase seeding experiments made in 1956 further emphasize the importance of clipping management during the year of establishment that reduce competition from weeds and/or a companion crop. In general, the alfalfa-bromegrass and trefoil-timothy associations were favored by only one clipping and the Ladino-orchardgrass by severe clipping.

Sub-project II - Persistence and Productivity. The alfalfa and Ladino clover management investigations were conducted at 4 locations, Maryland, New York, Rhode Island, and West Virginia. Results indicate that alfalfa can be harvested earlier in the spring than previously supposed. Alfalfa harvested at the full bud stage in the late spring produced high forage yields without stand reductions. However, early fall removal of a third hay cutting was most harmful to stand maintenance. Late fall forage removal (after killing frost) gave highest seasonal forage yields but produced forage of somewhat lower quality than earlier harvests. When alfalfa is grown with grass such as orchardgrass it is more sensitive to early cutting harvests than when seeded in pure stands.

Ladino clover stands in 1957 were severely reduced by the drought. Results indicate that Ladino clover survival is related to harvest management practiced. Survival of stands was favored by removal of the Ladino at the pasture stage and in the late fall. Delayed spring harvest and early fall forage removal were both detrimental to stand survival. Greater total forage production was obtained with Ladino when it was grown in grass associations and an orchardgrass-Ladino association was more productive than a bromegrass-Ladino association.

USEFULNESS OF FINDINGS:

These investigations are yielding much information on the factors that govern the establishment, production and persistence of several of the more important forage species within the region. Basic information on soil and particularly climatic conditions are being obtained which should be useful in interpretation of local conditions. It is already becoming apparent that competition between plants for moisture, particularly with weeds, is even greater than formerly assumed. Since three of the past four years during which the regional experiments have been conducted would be classed as dry years, it becomes apparent that the adoption of seeding management practices for minimizing competition for soil moisture will result in better stand establishment.

The results obtained on the management experiments will promote a better understanding of the responses of forage species to management practices which are productive of maximum yields and quality forage without reductions in stands. This regional research then cannot help but result in more intelligent management of forage crops in the Northeast.

WORK PLANNED FOR NEXT YEAR:

Data will be transferred to IBM cards for local and regional analysis and to aid in summarization of the results for publication. The last phase of field experimentation will be concluded in 1958. Plans have been made for the preparation of four regional publications on the work now being completed and for revision of the project during the ensuing year.

PASTURE RESEARCH AT STATE STATIONSCONNECTICUT (STORRS)

Title: ALFALFA EXPERIMENTS

Leaders: B. A. Brown, R. A. Peters and E. J. Rubins

(a) Fertilization (G3): In the third harvest season (1957), there were no appreciable differences in yields from four rates of banded vs. broadcasted superphosphate applied before seeding in July 1954. This is also true of the averages of 1955, 1956 and 1957. However, there have been trends toward higher yields as the rates of superphosphate (46%) increased from 90 to 720 pounds per acre. In general, the results indicate that the very stimulating effects of large amounts of banded P on seedling establishment may be obtained without suffering the penalty of decreased production in subsequent years.

On the same field as above, banded KCl (60%) had little effect at lower rates (50 and 100 pounds per acre) but was injurious to seedlings at the higher rates (200 and 400 pounds per acre). In spite of these seedling effects, stands and yields improved markedly with increased rates in 1955 with no additional K, and also in 1956 and 1957, when KCl was topdressed each year on all plots at 300 pounds.

The soil on G3 had a pH of 6.0 and a "medium" supply of Ca and Mg before treatment in 1954. Under those conditions banding of dolomitic limestone at 500 or 1000 pounds per acre had no effects on seedling establishment but those and heavier applications, mostly broadcast and disked in, have caused striking differences in stands and yields during the three harvest years. In 1957, the plots with limestone at 4000 pounds in 1954, had approximately double the stands and yields of the no-lime plots; the 8000 pound treatment was even better.

Field G15: For three years (1955-57) the effects of potash (K_2O) at 180 and 270 pounds, each with and without N at 180 pounds, on a Rhizoma alfalfa-timothy seeding under ten cutting systems, have been determined. In general, the stands of alfalfa have not been affected much by the extra 90 pounds of potash or by the nitrogen. Furthermore, the yields were not increased by the higher rate of potash but with the seven cutting systems which have been quantitatively harvested for three years, the 180 pounds of N have increased the average yields of dry matter by 1400, 300, and 300 pounds per acre for 1955, 1956, and 1957, respectively. Slightly larger increases were obtained from the N with Buffalo alfalfa in 1955 and 1956.

Field W22: In August 1956, this field was very liberally fertilized with disked-in limestone, superphosphate and muriate of potash, and seeded with three varieties of alfalfa at 10 pounds, each variety with three rates of timothy; each seed mixture was banded or broadcast with (1) no additional fertilizer, (2) with banded superphosphate (46%) at 200 pounds, and (3) with banded superphosphate as in (2) plus muriate of potash (60%) at 100 pounds. Quadruplicated 20'x7' plots were seeded with each treatment or a total of 216 plots. The stands and growth of the alfalfas were estimated two months after planting and those data are briefly summarized below:

1. DuPuits had better stands and greater top growth than Narragansett or Vernal in practically all comparisons and for 72 plots averaged 20 percent better stand and 50 percent taller growth.
2. Drilling the seed over banded P or PK averaged 10 percent more alfalfa with 10 percent more growth than where the seed was broadcasted with banded P.
3. In comparison with no additional fertilizer, banded P increased the stand of the alfalfas over 10 percent and their heights over 20 percent.
4. Including K with the banded P gave slightly poorer results than the P alone.
5. In most comparisons timothy at either 3 or 6 pounds per acre reduced the stands and growth of Vernal and Narragansett but, with a few exceptions, not DuPuits. Drilling the seed over banded P or PK tended to reduce the detrimental effects of timothy on the seedling growth of the alfalfas.

Based on dry matter yields for three cuttings in the first harvest year (1957), drilling the seed or including timothy was beneficial for Narragansett but not for DuPuits and Vernal. In all comparisons, DuPuits yielded more than Narragansett or Vernal and averaged, respectively, 20 percent and 12 percent more dry matter.

Pot Experiment: Using Paxton very fine sandy loam soil with a "medium" amount of available P before treatment, the following increases in root and top weights of seedling alfalfa from banded superphosphate were obtained.

Superphosphate (46%) Applied (Pounds per acre)	Percentage Increases in Seedling Growth of Alfalfa from "Banded" over "Mixed" Superphosphate	
	<u>Roots</u>	<u>Tops</u>
50	150	27
100	90	75
200	83	80
400	28	50
800	30	17
1600	4	21
3200	11	-7

These results illustrate the stimulative effects on seedlings of banded superphosphates in a soil sufficiently rich in P for maximum growth of mature plants.

This experiment was continued through six harvests of the alfalfa tops. The beneficial effects of banding the superphosphate were not large in any of the harvests but the rate was very important regardless of placement. For the final cutting the percentage increases in yields averaged as follows:

Superphosphate (46%) Applied (lbs./A) -	50	100	200	400	800	1600	3200
% Increase Over No Superphosphate	- 18	46	71	143	333	400	454

Muriate of potash (60%) at 400 pounds was a standard, "mixed-in" treatment for all cultures. Banding of additional muriate of potash at 400 pounds per acre with either the "mixed-in" or "banded" superphosphate had little effect on the growth of the alfalfa throughout the experiment. Chemical analyses of the forage are being made to determine if the K or Cl affected the absorption of P.

(b) Varieties: In the sixth harvest season (1957) only one (Cl80) of the sixteen unnamed strains had a poorer stand or smaller yield than Buffalo and Ranger, the best of fourteen named varieties. The five varieties with the highest average yields for six years were: Cl30, C223, Cl88, C57, and Cl90. They ranged from 64 to 68 cwts. dry matter per acre. The five varieties with lowest average yields were: Talent, Grimm, Variegated, Chilean and DuPuits (43 to 46 cwts. dry matter per acre). In all cases the yields include grasses and weeds.

Four variety tests were seeded in the spring of 1956. Due chiefly to the competition of weeds in 1956 and severe drought in 1957, stands were thin and weak until the latter part of the 1957 season. Under such conditions, DuPuits had the best stands and yields in all of the four tests. Narragansett and Vernal produced about the same, both being somewhat superior to Atlantic. In the one test in which they appeared, Buffalo and Ranger yielded appreciably less than the four varieties just discussed.

Of the unnamed varieties, Cl87, Cl99, NY 49-9, NY-A, NY-C, and Syn. A-239 appeared promising. The first two have done well throughout the six-year test reported above.

(c) Management: As stated in the 1956 report, ten cutting systems were initiated on Buffalo and Rhizoma alfalfa in the spring of 1955. At the end of the first season neither variety had much alfalfa left on plots cut 21, 28 or 35 day intervals and those systems were discontinued in 1956. Buffalo had poor stands under all systems after two years of cutting treatments and was discontinued in 1957. The trials were continued on Rhizoma in 1957 and in October of that year it had fair to good stands under all seven systems. Listed after the days between cuttings, the stands were: 42-42-84 - 90%; 28-42-42-56 - 84%; 28-35-42-63 - 77%; 42-42-42 - 74%; 35-42-42-49 - 73%; 42-42-42-42 - 68%; 42-42-56 - 67%.

The average yields of dry matter for four fertilizer treatments varied in 1957 from 5700 for the 35-42-42-49 system to 3700 for the 28-35-42-63 system. It is probable that the nutritional qualities of the forage from those two systems did not vary greatly if the entire season's production is considered.

Ladino Longevity and Yields: In 1954, the Ladino-grass seeding of 1939 was divided into three parts—one part for each replication or block of the ten former cutting management plots. One block has been harvested by mowing three to five times per season with each of the ten former plots divided in half, one-half receiving N at 50 pounds after each cutting, the other half receiving no fertilizer N. Both halves received liberal PK treatments. The four-year average gain for the 200 pounds of N is about 1000 pounds per acre of dry matter. Each year there was considerably less Ladino on the N halves of the plots, averaging about 60 percent as much clover in 1955 and 1956. Due to the very severe drought in 1957, Ladino declined to 5 percent without N and to only a trace on the N areas.

The other two blocks have been grazed four-five times each season. One receives N at 50 pounds after each grazing, the other no fertilizer N. Both are fertilized liberally with P and K. Clover was practically eliminated from the N paddock in one season, while 25 percent of the area had clover on the no-nitrogen pasture. The average results of the four-year grazing trials follow:

<u>Nitrogen Added</u>	<u>Heifer Days</u>	<u>Pounds Gained</u>
0	135	203
+	163	170

"K" Efficiency in the Fertilization of Ladino: In a six-year experiment—1950 to 1955—the same total amounts of KCl were more efficient in maintaining the stands and yields of a Ladino clover-orchardgrass seeding when the KCl was added four times instead of once per season (Agron. Jour. 49:477-480. 1957).

Analyses of 1956 samples have shown that the residual K in the soil was about twice as great where the KCl had been applied in the smaller, more frequent doses. The greater amounts of residual K in the soil were reflected in much better stands and yields in 1956 when no fertilizer was added.

It was also found that the leachability of the K from KCl was reduced 50 percent by applications of either dolomitic limestone or hydrated lime. However, this reduced leachability was not correlated with diminished absorption of K by the forages.

Trefoil Management: From two years of differential grazing management of six trefoil-timothy pastures, it appears that the legume thrives somewhat better under a hay-pasture system than where grazing whenever the trefoil is six inches high.

Title: USE OF HERBICIDES IN FORAGE CROP MANAGEMENT

Leaders: R. A. Peters and B. A. Brown

(a) Overwintering of Alfalfa as Influenced by Herbicides on Summer Seedings:

Alfalfa seeded August 6, 1956 was treated with several herbicides on August 30 in the second true-leaf stage. Mustard was seeded to insure a heavy weed infestation.

Control of mustard without injury to the alfalfa was obtained with neburon at rates of 1, 2 and 4 pounds per acre, and 2,4-DB at rates of $3/4$, $1-1/2$, and 3 pounds acid equivalent per acre.

Yields of alfalfa obtained in June of 1957 indicated a close correlation with the degree of winter heaving. In turn, the degree of heaving was related to the chemical treatment the previous year. In general, those plots treated with chemicals which controlled the mustard the previous fall without injuring the alfalfa had the highest second year yields. The more rapid establishment of the alfalfa plants released from fall weed competition resulted in less winter heaving. On the unweeded check plots, the stand count decreased from 30 per two square feet to 11 living plants per two square feet while the plots treated with neburon averaged 41 plants in the fall and 34 living plants in the spring and with 2,4-DB, 36 in the fall and 29 in the spring. Yields of alfalfa varied from 1333 pounds per acre in the unweeded check to an average of 3911 pounds when treated with neburon and 3100 pounds when treated with

2,4-DB. These results indicate a particular advantage in the use of herbicides in late summer alfalfa seedings to assure competition free establishment of alfalfa prior to the dormant season.

(b) Early Post-emergent Weed Control: Second year yield data were obtained from the experiment reported in the 1956 Annual Report, page 41.

The large differences in yield of alfalfa noted the seeding year following treatment were not reflected in yields taken in June 1957. Only the 2,4-D at 0.8 pound per acre caused a significant reduction in yield. In contrast, birdsfoot trefoil yields were much higher the second year on those plots on which good weed control was obtained the seeding year. The best treatment combination (Dalapon plus 2,4-DB) gave a second year yield over ten times as great as the non-weeded check.

Another experiment was laid down in May 1957 similar in pattern to that of 1956. The species included were Vernal alfalfa, Viking birdsfoot trefoil and Ladino clover. The principal weed present was a heavy stand of volunteer lambsquarter. The treatment results obtained were in some regards quite different from those obtained in 1956. The growing season was markedly low in precipitation compared with the more nearly normal season of 1956. The substituted ureas, neburon, monuron and diuron displayed only slight activity in the 1957 tests when no rain occurred for several weeks after application. The exception was Ladino clover which was injured on contact by diuron, monuron, and neburon in order of severity. The effectiveness of 2,4-DB was not decreased by the drought conditions prevailing in 1957. Since weed stands during this period of moisture stress maximized the competitive effect, rather striking increases in yields from weed control were obtained. The use of 2,4-DB at 1-1/2 pounds per acre increased the yield of alfalfa sampled eight weeks after treatment from 204 to 722 pounds per acre, of birdsfoot trefoil from 33 to 704 pounds per acre and of Ladino clover from 2 to 114 pounds per acre. The three species varied in response to release from weed competition. Percentagewise, yields were increased in this order: Ladino clover, birdsfoot trefoil, and alfalfa.

Remarkable recovery was made by Ladino clover when conditions became favorable after clipping and moisture became ample. The check increased from 2 in August to 240 pounds per acre in October. In contrast, the vigor of birdsfoot trefoil remained low in the check plots when growth conditions again became favorable. In terms of the stands obtained by the end of the first season, birdsfoot trefoil responded the most from weed control.

(c) Late Summer Seeding of Legumes in Companion Crops: Pure seedings of legumes in late summer have generally been recommended rather than seedings in companion crops since moisture stress is most likely during this period. Observations made at Storrs in 1956 and 1957 have indicated that under Connecticut conditions it may be feasible to make seedings in an oat companion crop during August with the oats being available for late fall pasturing. Alfalfa seeded August 25, 1956 and sampled for yield September 3, 1957, yielded more when seeded with oats than when seeded alone. The increase was attributed to decreased heaving on plots having oat stubble over the winter.

MAINE

Title: FORAGE BREEDING AND VARIETY TESTING

Leader: C. R. Blackmon

Red Clover: The 1955 red clover variety plantings persisted into 1957 but with reduced stands and yields. Wisconsin Synthetic and Dollard gave the best yields for the two-year period. The average dry weight yields of the red clover varieties in tons per acre in 1957 were: Wisconsin Syn. 2.1, Dollard 2.1, Kenland 1.9, Midland 1.8, and Pennscott 1.6. Wisconsin Synthetic continues to be outstanding in resistance to northern anthracnose and mildew, with Pennscott, Midland and Kenland very susceptible. A new red clover variety nursery was established at Orono and a disease nursery at Presque Isle.

Soybeans: Twenty-four soybean hybrid selections were yield tested in 1957. Several of these selections appeared adapted and seed will be increased for large scale testing.

Observation Nursery: Sixty-four varieties of various grasses and legumes were established in an observation and screening nursery to determine their adaptation to Maine.

Domestic Exploration Nursery: Several new alfalfa and red clover selections from throughout Maine have been established in this nursery.

Title: TIME AND RATE OF NITROGEN ON GRASS

Leaders: C. S. Brown and P. N. Carpenter

Yield and nitrogen recovery data were obtained for the third harvest year from the experiment sown in 1954 (1954 Annual Report, page 29). Yield responses were of the same order as in 1956, but about one-half ton lower. Drought was more severe. A marked ingress of Kentucky bluegrass was noted in the brome-grass and timothy plots. Orchardgrass plots were still virtually free from bluegrass. Nitrogen release by the soil continued to decline in the absence of legumes. The average nitrogen removal from check plots has been as follows: 72 pounds N in 1955, 20 pounds in 1956, 13 pounds in 1957.

Title: TIME AND RATE OF NITROGEN ON LEGUME-GRASS

Leader C. S. Brown

The study with Ladino-timothy and Viking trefoil-timothy was continued (1956 Annual Report, page 46). Nitrogen had little effect on Ladino survival in the early cut series, but resulted in a marked reduction in the late cut series. Overall, late cutting was more detrimental than nitrogen. Botanical separations in September showed 36% Ladino in the June cut plots and 9% Ladino in the plots cut first in July. Late cutting had little effect on trefoil survival except when combined with high nitrogen.

Title: RATE OF NITROGEN, PHOSPHORUS, AND POTASSIUM ON TIMOTHY

Leaders: P. R. Belyea and C. S. Brown

A study of the effect of topdressed N-P-K on the yield and chemical composition of timothy harvested twice annually for hay was continued for the second harvest year. Nitrogen treatments ranged from 0 to 300 pounds N, phosphorus from 50 to 150 pounds P_2O_5 , and potassium from 50 to 300 pounds K_2O .

The low rate of potassium (50 lb. K_2O) proved inadequate at 200 and 300 N. Severe deficiency symptoms were observed in the second cutting, more pronounced than in 1956. Total dry matter yields were increased 1400 pounds and 900 pounds on the two soils when an additional 100 lb. K_2O was supplied. No response to phosphorus above the low rate was obtained.

Title: RATE OF LIME, PHOSPHORUS, AND POTASSIUM ON LEGUME-GRASS

Leader: C. S. Brown

An experiment to compare alfalfa, trefoil, and red clover at different lime and fertility levels was begun in 1955 on a moderately well-drained Dixmont silt loam. Lime rates were 2 and 7 tons per acre, resulting in final pH values of 5.7 and 6.3, respectively. Annual fertility treatments ranged from 60 to 120 pounds P_2O_5 and 40 to 320 pounds K_2O . Narragansett alfalfa, Viking trefoil, and Kenland red clover, sown with Climax timothy, have been used. Two hay cuts have been made annually. Alfalfa has been markedly superior to red clover or trefoil in all treatments. The survival and yield of alfalfa at the low lime level has been good, and may be explained by the presence of natural limestone underlying the soil used. At the higher fertility levels, dry matter yields in 1957 were 6300 and 6900 pounds for the low and high lime treatments, respectively. Stands still contained approximately 80% alfalfa in the August 1957 cut. However, reduction in vigor at low lime was apparent in the fall regrowth.

MARYLAND

Title: LADINO CLOVER BREEDING

Leaders: R. C. Leffel and A. Morris Decker, Jr.

Two tests, polycrosses of 13 clones and a strain and synthetic test, were established at College Park in the spring of 1957. Stands and vigor were excellent in the fall of 1957. Ten Pasture Laboratory clones and three parental clones of Pilgrim Ladino have been vegetatively increased in the greenhouse in preparation for production of polycross seed among these 13 clones during the summer of 1958.

Title: IMPROVEMENT OF RED CLOVER ADAPTED TO MARYLAND

Leaders: R. C. Leffel and A. Morris Decker, Jr.

Chesapeake, a local strain of red clover, was released in December, 1957. During the past ten years local strains within the state have been collected and tested. Much of this material has been subjected to several generations of maternal line selection. Resistance to southern anthracnose, (Colletotrichum trifolii), has been emphasized in this program. An evaluation of progress made to date is planned for 1958 and subsequent years.

Topcross and polycross progenies of certain lines demonstrating resistance to Colletotrichum trifolii and a high degree of persistence are being evaluated. An experiment to determine the effect of natural selection on selected strains of red clover is being conducted cooperatively by the Maryland and Kentucky Experiment Stations.

Title: ORCHARDGRASS BREEDING

Leaders: R. C. Leffel and A. Morris Decker, Jr.

Evaluation of approximately 3,000 spaced-plants (polycross progenies) was continued. It does not appear that this source nursery contains material superior to certain clones concurrently tested in the N.E. 28 Regional Orchardgrass Tests.

Title: VARIETY AND STRAIN TESTING OF FORAGE LEGUMES AND GRASSES

Leaders: R. C. Leffel and A. Morris Decker, Jr.

Alfalfa: Williamsburg and Narragansett have produced high yields of forage consistently at locations throughout the state since 1951. Performance of Buffalo and Atlantic has been satisfactory. Sockeirlle and DuPuits were highly productive in each of the past four years in an alfalfa variety test at College Park and will be extensively evaluated in the future.

Red Clover: An extensive program of testing local and released strains of red clover has been in progress since 1949. A local strain, released as Chesapeake in December 1957, has been outstanding in yielding ability and persistence during this period. Several other local strains appear promising. Pennscott and Kenland have been satisfactory but inferior to Chesapeake in performance.

Ladino Clover: All Ladino clovers have demonstrated an inability to maintain themselves in long-time forage stands. Pilgrim has been the most consistent producer of high yields of forage.

Orchardgrass and Tall Fescue: Alta and Kentucky 31 fescues have been quite similar in performance. Potomac and Commercial orchardgrass have been most productive among orchardgrass strains tested to date.

Bermudagrass: Results of first year harvest yields of five varieties tested at three locations were rather striking. Midland, Greenfield and Common survived the 1956-57 winter in fine condition, while Coastal and Suwannee were

essentially eliminated. Midland was most productive at all three locations (5.70 T/A) followed by Greenfield (5.02 T/A) and Common (2.57 T/A). By the end of the 1957 growing season Coastal had reestablished itself at each of the 3 locations, while Suwannee was found only at one location.

Title: NITROGEN FERTILIZATION OF PURE GRASS AND GRASS-LEGUME ASSOCIATIONS

Leader: A. Morris Decker, Jr.

Six grasses grown alone and with a legume each under three nitrogen levels, were harvested for the third harvest year (1956 Annual Report, page 49). Total weed-free forage yields during an extremely dry summer ranged from 2.21 tons for Kentucky bluegrass-white clover plus 50 lbs. of nitrogen to 8.42 tons with Midland bermudagrass with 300 pounds of nitrogen. In most cases where 50 lbs. of nitrogen were added to a grass-legume mixture each year for the past three years, total 1957 forage production was less than where no nitrogen had been applied. Results during these past three years demonstrate that under the light, sandy Coastal Plain soils of Southern Maryland it is often easier to maintain forage yields by the use of commercial nitrogen than to attempt to maintain legumes for this purpose. Indications are that it will also be more economical over a period of years.

Title: **RESPONSE OF ORCHARDGRASS TO VARIOUS RATES AND RATIOS OF POTASSIUM AND NITROGEN FERTILIZATION**

Leader: S. E. Younts

Plots of orchardgrass were established in September 1957 to study the effect of various rates and ratios of nitrogen and potassium fertilization on yield, longevity of stand and chemical composition of forage. Beginning in the spring of 1958 four rates of nitrogen (50, 100, 200, and 400 lbs./A) and five rates of K_2O (0, 50, 100, 200, and 400 lbs./A.) in a complete factorial are to be applied each year with the P_2O_5 rate at 100 pounds per acre for all treatments. In addition, fall vs. spring applications of nitrogen will be compared.

Title: TIME AND RATE OF POTASSIUM APPLICATION TO ALFALFA AND ALFALFA-ORCHARDGRASS

Leader: S. E. Younts

An experiment was initiated in the fall of 1957 to study the effect of time and rate of potassium applications to alfalfa and alfalfa-orchardgrass. The objectives of this study are: (1) to determine the most efficient rate and time of applying potassium to alfalfa and alfalfa-orchardgrass, (2) to study how alfalfa and alfalfa-orchardgrass differ in potassium requirements, and (3) to what potassium contents in harvested forage are critical for maximum yield and stand persistence. Potassium rates from 0 to 400 pounds of K_2O per acre are being applied in 6 different ways.

Title: COMPARISON OF NITROGEN SOURCES ON ESTABLISHED BLUEGRASS SOD

Leader: S. E. Younts

In the spring of 1958 five rates of nitrogen up to 480 pounds per acre from four sources - urea-formaldehyde, urea, ammonium sulfate and ammonium nitrate - are to be applied to established bluegrass sod. The purposes of this study are: (1) to compare the four carriers as nitrogen sources, (2) to determine seasonal availability of nitrogen from single and split applications of these sources, and (3) to study the effect of the four sources on yield and nitrogen content of grass produced.

Title: GRASS AND LEGUME COMBINATIONS FOR BEEF PRODUCTION

Leader: A. Morris Decker, Jr. and Robert Z. Spry

Evaluation of four pasture combinations for beef production in the Coastal Plains area of Maryland was continued for the second year (1955 Annual Report, page 47 and 1956 Annual Report, page 49). Beef production was highest for Bermudagrass-rye followed by orchardgrass-ladino clover, Kentucky bluegrass-white clover and reed canarygrass-ladino clover. The Bermudagrass combination was substantially higher in both beef production per acre and days of grazing. Seeding a small grain such as rye in Bermudagrass (Midland) sod appears to have a real potential with regard to beef production in this area.

Title: EFFECTS OF IRRIGATION AND FERTILIZATION ON FIVE FORAGE SPECIES
GROWN ON MONMOUTH LOAMY, FINE SAND SOIL

Leader: A. Morris Decker, Jr.

In the fall of 1957 an irrigation experiment involving three grasses (Kentucky 31 fescue, Kentucky bluegrass and Midland bermudagrass) and two legumes (alfalfa and Ladino clover) was seeded. A split plot design was used in which irrigation levels (three) made up the whole plot, species (five) made up the sub-plots and fertility levels (three) made up the sub-sub-plot. Moisture treatments are: (1) normal rainfall, (2) irrigation only at high moisture tensions, and (3) soil moisture maintained at a low tension. Annual nitrogen applications of 100, 200, and 400 pounds will be used on each of the grasses in four equal applications. The two legumes will be fertilized with 500, 1000, and 1500 pounds of an 0-15-30 fertilizer annually.

Good stands of all species were obtained in the fall of 1957 and were apparently not damaged during the 1957-58 winter period.

This experiment was first seeded in the fall of 1956, but poor stands made the second seeding necessary. Harvests were made on the tall fescue plots during the 1957 growing season. Dry matter production ranged from 2.83 tons per acre without irrigation and 75 lbs. of nitrogen to 7.36 tons per acre with a total of 1.5 inches of water per week and 300 lbs. of nitrogen.

MASSACHUSETTS

Title: EFFECT OF N AND K ON YIELD, COMPOSITION, AND LONGEVITY OF ALFALFA
WITH ORCHARDGRASS AND LADINO CLOVER WITH ORCHARDGRASS

Leaders: Mack Drake and John White

This experiment was seeded August 25, 1953 on a Merrimac fine sandy loam. Before planting two tons of dolomitic limestone and 400 lbs. 8-8-8 were broadcast and worked into the surface 4 inches. In addition, 800 pounds of 20% superphosphate was drilled 2-3 inches deep and allowed to remain in bands about 7 inches apart. It is believed that dolomitic limestone and phosphorus were supplied in adequate amounts. One ton of dolomite was applied in July 1955. Soil tests showed pH 6.7 after third harvest year (1956). In addition to the 3 levels of N (nitrogen) x 3 levels of K (potassium) a tenth treatment received 50 lbs. P_2O_5 after the first cutting each year. These phosphorus applications did not increase yields of either alfalfa or Ladino clover with orchardgrass. In several cases the percent phosphorus in the plant material was increased slightly by the annual topdress application of superphosphate.

Potassium was supplied at three rates. The lowest rate, 150 pounds of K per acre (50 lbs. after 1st, 2nd, and 3rd cutting) on alfalfa, orchardgrass, the first and second harvest year proved adequate, since 300 and 450 pound rates did not increase yields. Likewise on Ladino-orchardgrass, 165 pounds K (33 pounds after each of 5 cuttings) the first year and 100 pounds of K (33 pounds after each of 3 cuttings) the second year appeared adequate. Rates at 2 and 3 times these levels did not increase yields. In planning this experiment it was estimated that the lowest level of K would be inadequate at the medium or highest N level. This might have occurred if the nitrogen applications had been more liberal and if time of application had been 50% in April and 25% after 1st and 25% after 2nd cutting as was the practice in the 3rd harvest year.

In 3 years alfalfa-orchardgrass yielded 21565, 26203, and 28184 pounds of dry matter respectively with 0, 225, and 450 pounds of applied N. If one prices N at 14 cents per pound and hay at \$40. per ton or 2 cents per pound, 225 pounds N at \$31.50 produced an increase of 4637 pounds of hay worth \$92.74. Four hundred and fifty pounds of N at \$63. produced an increase of 6639 pounds of hay worth \$132.78. The increase of 4637 pounds of hay produced by 225 pounds of N is at the rate of 20.6 pounds of hay per pound of N applied for alfalfa-orchardgrass. The increase of 6639 pounds of hay for 450 pounds of N was at the rate of 14.7 pounds of hay per pound of N applied.

In 3 years Ladino-orchardgrass yielded 16433, 18723, and 20591 pounds of hay respectively for 0, 200, and 400 pounds of applied N. Two hundred pounds of N at \$28. produced a hay increase of 2290 worth \$45.80. Four hundred pounds of N at \$56. produced a hay increase of 4158 worth \$83.16.

Yield response to N was much greater for the alfalfa-orchardgrass than for Ladino-orchardgrass. Since all stands were about 50-50 legume-grass distribution, it appears that alfalfa produced an important yield response to applied nitrogen.

At 225 pounds of applied N, alfalfa-orchardgrass yielded an increase of 20.6 pounds of hay per pound of N and at the 450 pound rate of N the increase was 14.7. In contrast, the Ladino-orchardgrass with 200 pounds of N produced a yield increase of 11.5 pounds of hay per pound of N and 400 pounds of N produced 10.4 pounds of hay.

With no added N: in the first harvest year Ladino-orchardgrass produced 6% greater yields than alfalfa-orchardgrass. However, in the second and third harvest years Ladino-orchardgrass yielded only 43% and 78% respectively as much as alfalfa-orchardgrass.

Title: INSECTS IN RELATION TO FORAGE CROPS IN MASSACHUSETTS

Leaders: F. R. Shaw and R. J. Lavigne

Systematic surveys of insects attacking forage crops were continued during 1957. Discovery of the alfalfa weevil, Hypera postica (Gyll) in Hampden and Berkshire counties in June and in Bristol County in September was the most important single fact observed.

Preliminary investigations initiated in 1957 demonstrated the presence of large numbers of clover root weevils Sitona spp. The following data are fairly typical:

<u>Type of Forage</u>	<u>No. immature weevils per sq. ft. in soil 6" deep</u>
Alfalfa (Narragansett)	139
Ladino clover	119
White clover	112
Red clover	95
Birdsfoot trefoil	29

Such high populations would indicate the probability that these insects may be of major importance in the failure of certain legumes to maintain stands in the state.

Weekly surveys of the population of insects attacking alfalfa foliage indicate that the more important pests in order of their abundance are aphids, leafhoppers, alfalfa plant bugs, tarnished plant bug, meadow spittle bug and the Japanese beetle.

A statewide survey of insect pests of forage crops was made in September. One of the results of this survey was the indication that meadow spittlebug on alfalfa would be of minor importance during 1958.

NEW HAMPSHIRE

Title: IMPROVEMENT OF SMOOTH BROMEGRASS, RED CLOVER AND ALFALFA

Leaders: G. M. Dunn and L. J. Higgins

Bromegrass crossing was continued in the greenhouse, following hot water emasculation (1956 Annual Report, page 54). The more self-fertile plants again produced more cross-pollinated seed than relatively self-sterile plants. Considerably better seed set was obtained than in the previous year; some plants averaged 300-350 seeds per 4 panicles. Data were obtained on self- and cross-fertility of these clones in the field. Some of the clones crossed in 1956-57 may not have been completely emasculated (46° C. for 5 minutes). Seedling markers are needed to identify crosses. An attempt will be made to relate fertility to chromosome numbers and pairing.

Selection was continued for brown spot resistance with generally poor results on artificial inoculations. Results to date indicate that considerably more work is needed on cultural and physiological studies with this organism. Several media were tried for conidial production; of those tested, "V-8" agar appeared most promising. However, poor infection was obtained in some trials with cultures containing conidia. Some S₁ lines were considerably better than open-pollinated lines in field reaction to brown leaf spot.

Six bromegrass synthetics were seeded in the fall of 1957. Selection was based primarily on brown spot resistance and recovery. Polycross seed will be obtained on 144 selections in 1958.

Yield data were not taken on the Colebrook bromegrass test seeded in 1952. Stands of Fischer and northern bromegrass types were better than other varieties in the fifth season.

The alfalfa test seeded at Colebrook in 1956 included Narragansett, Vernal, DuPuits and Ranger without grass. A poor stand was obtained for all varieties except DuPuits, and this variety produced a significantly higher yield in 1957. Ranger was lowest in stand and yield.

The potted New Hampshire red clover plants in the greenhouse produced some seed as a result of crossing by the first bees which appeared in the spring. Additional seed was obtained from a small isolated increase plot established in 1956.

The replicated variety trials seeded in 1956 were harvested June 13, 1957, but the yields were very variable since three poor areas were present in the plots. The New Hampshire red clover yielded an average of 3.02 tons to the acre and was high, partially due to only one poor replication, while several of the other varieties had two or more poor replications. The second cutting was not harvested due to the extended drought.

Title: IMPROVEMENT OF WHITE CLOVER

Leaders: G. M. Dunn and R. A. Kilpatrick (in cooperation with Forage and Range Research Branch, A.R.S., U.S.D.A.)

Surveys of diseases attacking white clovers were continued in 1957. Essentially the same diseases were found in 1957 as in 1956, although the severity of the disease varied with location and seasonal weather conditions.

A new disease of clovers caused by a yeast fungus was found on leaves and seeds of different Trifolium spp. The fungus caused premature defoliation; in some plots, 25 percent of the leaves were killed. The fungus attacks several leguminous plants. A disease of white clover caused by a yeast previously unreported on clovers in the United States was found in two locations in New Hampshire. The fungus produces lesions on leaves of clovers and other legumes similar to bacterial leaf spot. A pitting of clover seed is also associated with the disease.

Greenhouse inoculations were continued with Curvularia trifolii. Thirty-two selections have been made for resistance from approximately 14,000 seedlings. These plants were intercrossed with bees in the greenhouse, and transferred to the field for agronomic observations. Approximately 4,000 of the open-pollinated seedlings from these 32 selections were inoculated, and 430 plants were selected for resistance. Seed lots from Oregon have shown greater promise for resistance than other seed sources.

Root rot observations were continued on 4 strains of white clover at 2 locations. Taproots were sampled at 4-6 week intervals and rated for severity of rot. The root rots became progressively worse with increased age of plant. Rotting was most severe in areas heavily infested with larvae of the clover root curculios, Sitona spp. Plots of Wisconsin white clover were virtually eliminated by the end of the first harvest season. Many taproots were practically dead and a large percentage were badly rotted when the plants were 17 months old.

Isolations were made from diseased roots throughout the growing season. Fusarium oxysporum isolates increased following periods of heavy larval population in the spring and fall. A greater number of fungi were isolated during these periods. Sampling will be continued in 1958. Plots will be established, in cooperation with the Entomology Department, to determine if Sitona spp. can be controlled with insecticide, and to study the relationship of these insects to root diseases and clover survival.

Yield data were obtained on 7 strains of white clover seeded at Colebrook in 1956. The design was a split plot, Ladino alone and with brome grass, in 4 replications. Ladino alone produced 3,000 pounds dry matter compared to 4,365 pounds with brome grass. The strains did not differ significantly for total yield, including the grass fraction. Some strains were better than others for the clover fraction:

<u>Strain</u>	<u>lb./dm/A.</u> <u>Clover Fraction</u>
Western Composite	2745
Oregon (FC24060)	2800
Vermont Polyploid	2291
Wisconsin White Dutch	2190
Pilgrim	2957
Iowa Synthetic	2800
Minnesota Synthetic	2469

Rapid loss of stand occurred in Wisconsin white clover after flowering.

Because of severe drought, only one harvest was obtained on the Ladino test seeded at Dover in 1955. Loss of stand was more severe in 1957 in plots originally seeded to a Ladino-brome grass mixture than Ladino alone, apparently due to competition for moisture.

A polycross progeny test and a new breeding nursery were established in 1957. Four Ladino synthetics were produced.

Title: A PRELIMINARY INVESTIGATION OF FORAGE INSECTS IN NEW HAMPSHIRE

Leader: William R. Lee

Preliminary investigations on forage insects indicated a large number of larvae of Sitona spp. (as high as 54 per square foot) feeding on white clover roots in plots at Durham, N.H., used by Dr. G. M. Dunn and R. A. Kilpatrick for improvement of white clover. Larval populations reached a peak in early June and then decreased until no larvae or pupae were found from late July until early September (this may be abnormal because of the unusually dry summer). A second peak in larval population was reached in early October (maximum of 19 per square foot). It is not known whether the fall larval population developed from eggs which were laid by overwintered adults or newly emerged adults. The species composition of these two larval populations is also unknown; however, adults of both the clover root curculio, Sitona hispidula (F.), and S. flavescens Marsh. were found in sufficient abundance at Durham, N.H., and throughout the state to indicate that they are both of economic importance. This project has been changed to study the life cycle of S. hispidula (F.) and S. flavescens Marsh. and the relation of the larval feeding to root rot disease.

Title: SOIL FERTILITY STUDIES OF FORAGE CROPS**Leaders: A. B. Prince and P. T. Blood**

An experiment is being conducted at two locations to study the effects of lime, phosphate, and potash applications on the yields of alfalfa-smooth brome-grass and Ladino clover-smooth brome-grass mixtures. At Colebrook, New Hampshire, liming a Worthington loam soil from pH 5.5 to 6.5 markedly increased the total yield and the percent of alfalfa in an alfalfa-brome-grass mixture for the years 1956 and 1957. In 1956, the total yield for the Ladino clover-brome-grass mixture was more than double that of the alfalfa-brome-grass mixture. In 1957, the total yield for the Ladino clover-brome-grass mixture was significantly higher at pH 5.5 and significantly lower at pH 6.5 than the yield of the alfalfa-brome-grass mixture. The beneficial effects of annual applications of 100 pounds P_2O_5 per acre as compared with 50 pounds per acre on yield of the two mixtures were indicated in the 1957 data.

Title: WATER AND FERTILIZER REQUIREMENTS OF SELECTED CROPS AND SOILS AS RELATED TO SUPPLEMENTAL IRRIGATION**Leaders: A. B. Prince, P. T. Blood and R. S. Palmer (SWCRD, A.R.S., U.S.D.A.)**

Brome-grass was grown on an Agawam sandy loam soil with four levels of N and 3 levels of irrigation. Analyses of the forage for protein content showed that the highest percentage of protein was obtained in the last clipping, while the highest total production was obtained in the first clipping. Top-dressing with N markedly increased total protein production. Irrigation also increased protein production, but much less than N topdressing.

Brome-grass and Ladino clover also were grown on the same soil with 4 levels of Mg and 3 levels of irrigation. Analyses of the Ladino fraction of the first and last clippings for Mg, K, Ca, and P indicated the following: (1) despite topdressing with Mg, K, and P and irrigation, the mineral content of the last cutting was substantially lower than the first cutting; (2) the mineral content of the Ladino forage within a single clipping was relatively constant regardless of Mg or irrigation treatment; and (3) there was a tendency, although only slight, for the Mg, K, Ca, and P content of the Ladino to increase under irrigation.

Frequent clipping of the brome-grass resulted in loss of stand after the first harvest year.

Title: EFFECT OF HEAVY FERTILIZATION OF THE SOIL ON THE NUTRITIVE VALUE OF TIMOTHY

Leaders: H. A. Keener, F. E. Allen, A. C. Paul and H. A. Davis with cooperation of E. J. Thacker and K. C. Beeson, U. S. Plant, Soil and Nutrition Laboratory, Ithaca, N. Y.

Work carried out previously indicated that timothy hay grown under heavy fertilization was low in both trace minerals and some unidentified organic factor needed for growth in rabbits. In studies with calves the addition of both copper and iron to a timothy-containing ration deficient in these elements did not increase body weight gains. Replacement of part of the concentrates with an equal amount of net energy from dehydrated alfalfa increased body weight gains of calves by 20%. It would appear that alfalfa may contain the deficient factor.

The 1957 crop of timothy does not appear to be deficient in the organic factor. This is indicated by studies with both calves and rabbits. It appears that the dry weather of last summer may have brought about this situation by reducing the yield.

Title: ECONOMIC EVALUATION OF FORAGE PRODUCTION AND UTILIZATION IN NEW HAMPSHIRE

Leaders: G. E. Frick (Farm Economics Research Division, ARS, USDA) and F. S. Prince

Thirty crop-year records for 15 specialized dairy farms are being summarized. For each farm a detailed farm map showing field boundaries and soil types was made. A record of specific crop practices was itemized for each field. Each cooperating farmer kept daily records of both feed inputs and yield of crops and production of milk. This involved listing the amounts of grain and other concentrates and harvested forages fed, and the number of livestock on various pastures. For field crops raised and harvested a record of quantities harvested was kept to estimate total forage production. The farms were visited regularly during the crop year, and the pastures judged in terms of yield, quality of stand, and general management.

Estimates of the yield of pasture by grazing have been made for each field situation. These estimates have been adjusted by such items as associated feeds consumed, and the level of milk production, corrected for freshening patterns bias. Work is now in progress to associate the level of management of each particular field to the quantity and quality of forage produced. An effort also is being made to correlate yields to soil type and levels of management. Preliminary results indicate distinct relationships between farms in the study in terms of rate of milk production, and quality and quantity of pasture produced. The final objective is to appraise the effect on net farm income of various levels of management.

NEW JERSEY

Title: GENETICS AND BREEDING OF FORAGE LEGUMES

Leaders: W. R. Battle and W. Jurgelsky, Jr.

Studies of the inheritance of feeding value in alfalfa were continued. Earlier phases of the work established wide variations between clones in content of protein, carotene and xanthophyll, and in morphologic characters associated with forage quality. Inter-relationships among the characters were measured. Based on this information, selected plants were inbred and crossed in varying combinations. The resulting I_1 and F_1 families have been analyzed chemically, and the performance of the progenies compared with that of their parents. Parents high in carotene, xanthophyll or nitrogen content produced progenies higher in these constituents than did low parents, when both were crossed on the same or comparable clones. Inheritance of forage yield and of percent dry weight was not shown. No differences were found between reciprocal crosses for any characters studied. Polycrossed seed and selfed seed was harvested from all plants for use in further studies.

Seed was harvested from individual lines of bacterial wilt resistant Atlantic alfalfa. This will be used in making up experimental synthetic varieties for testing in comparison with the original Atlantic, and with other standard varieties.

Title: EVALUATION OF FORAGE STRAINS AND VARIETIES

Leaders: W. R. Battle, R. A. Cappellini, R. S. Filmer and B. Vuckovic

Severe drought conditions depressed the yield of all forages studied, but emphasized differences in their drought resistance. Red clover was injured much more seriously than was alfalfa, while birdsfoot trefoil was damaged most of all. Among the forage grasses, timothy, which is primarily a one-cut species, gave best results. Orchardgrass was greatly reduced in yield, and brome grass was reduced even more. Grasses grown alone gave higher yields than those grown in mixtures with legumes, probably because of differences in competition for moisture.

Soil applications of Lindane resulted in a 12 percent increase in first harvest yields of red clover. Drought obscured the effects on later growth, but a marked reduction in numbers of root chewing insects was noted where Dieldrin had been applied.

National usage of Atlantic alfalfa has reached about two million acres annually. More than 60 percent of all the alfalfa grown in New Jersey is Atlantic. The benefits of this usage are reflected both in increased forage yields and in greater persistence of stands.

Title: YIELD AND PROTEIN CONTENT OF GRASSES WHEN FERTILIZED WITH HEAVY RATES OF NITROGEN

Leaders: C. Eby and C. H. Ramage

These studies initiated in 1953 have indicated yield potentials available from orchardgrass and reed canarygrass with varying rates of nitrogen from 0 to 300 pounds per acre. Supplementary applications of potassium and phosphorus have been made to equate the total applications to a formula approximating 10-5-10.

1956 was a season of normal rainfall and extremely good distribution. 1957 was a season of extremely low rainfall and, accordingly, limited soil moisture. The table listed below indicates clearly the advantage of high rates of fertility in terms of yield. This is particularly interesting when comparing these two years. It is encouraging that, with high rates of fertility, yields during a very dry year are maintained at high levels.

Yields of forage and percentage of protein of orchardgrass and reed canarygrass in 1956 and 1957, at the Dairy Research Farm, Sussex, New Jersey.

Nitrogen treatment (pounds per acre)	<u>Orchardgrass</u>			
	1956		1957	
	Dry matter	Protein	Dry matter	Protein
	yields lb./acre	%	yields lb./acre	%
0	3496	12.52	3256	11.76
50	4233	12.55	3980	12.56
100	4649	12.17	4941	12.57
200	7070	14.61	6340	15.35
300	8187	14.88	6938	17.41
<u>Reed canarygrass</u>				
0	3633	13.14	2712	14.93
50	4505	13.44	4031	17.02
100	5097	13.30	4643	17.04
200	7868	14.87	6250	18.70
300	9104	15.02	6941	20.91

Title: FERTILIZER STUDIES WITH ALFALFA

Leaders: G. H. Ahlgren and J. L. Gerwig

Applications of fertilizer to the alfalfa study initiated in 1952 (Annual Report 1956) continued for the fifth consecutive year and harvests were made during 1957. Potash continued to be the key item with respect to yield and persistence of stand. The use of nitrogen and the time of application of P and K had no bearing on their effectiveness. For the first year, applications of boron were reflected in greater yields. Stands of alfalfa March 1, 1958 ranged from 3% on 0-100-0 plots to 92% and 93% on plots receiving 300 and 400 pounds K_2O per acre per year. On plots receiving 50 and 100 pounds K_2O (plus 100 pounds P_2O_5) stands were 29 and 36% respectively.

Table 1. The yield of alfalfa as influenced by different rates of nitrogen with P_2O_5 and K_2O held constant.

Fertilizer applied yearly in March	Dry Matter - Tons per acre of alfalfa 1957
0-0-0	0.05
0-100-200	2.96
25-100-200	2.99
50-100-200	2.33
100-100-200	2.40
200-100-200	2.03

Table 2. The yield of alfalfa as influenced by different rates of K_2O with no nitrogen applied and P_2O_5 held constant.

Fertilizer applied yearly in March	Dry matter - Tons per acre of alfalfa 1957
0-0-0	0.05
0-100-0	0.06
0-100-50	1.91
0-100-100	2.37
0-100-200	2.96
0-100-300	2.93
0-100-400	2.91

Title: STUDY OF THE EFFECT OF APPLIED N AND K, AND FREQUENCY OF CUTTING,
UPON YIELD, QUALITY AND LONGEVITY OF STAND OF ATLANTIC ALFALFA

Leader: E. R. Purvis

Soil: Nixon sandy loam, pH 6.2.

Treatments: (1) No N + 200 lbs. K_2O , (2) No N + 300 lbs. K_2O , (3) 200 lbs. N + 200 lbs. K_2O , and (4) 200 lbs. N + 300 lbs. K_2O .

Half of each plot receiving above treatments was harvested 3 times annually, and other half was cut 4 times. All treatments applied before growth starts in spring. No P applied during study.

Results from 5 Years of Study: N treatment has increased total yield by approximately 1 ton per acre, and protein yield by approximately 600 pounds per acre, where plots were harvested 4 times annually. Differences disappear when N treated plots are harvested 3 times at normal early bloom stage. Cutting 4 times in pre-bloom stage has removed 65 percent more K in plant material than has cutting 3 times. Plants on plots receiving N, harvested 4 times, have removed more K than applied in both K treatments, and this removal is reflected in soil tests. Some evidence of return of K from plant to soil in late pre-bloom and early bloom stages.

Title: PASTURE RENOVATION STUDIES

Leaders: M. A. Sprague, R. J. Aldrich and T. O. Evrard

Trials initiated during previous years were harvested and botanical compositions made during 1957. They continued to favor the use of chemicals and reduced tillage in the preparation of pasture seedbeds in most instances. Studies were undertaken to evaluate chemicals for this purpose. Among the most promising was dalapon at 4 pounds followed in a split application with cacodylic acid (2 pounds) the day of seeding. Cacodylic acid at 5 pounds followed by 2 pounds of cacodylic acid the day of seeding looked equally promising. The tillage required varied from 0 to the equivalent of 2 to 10 diskings depending upon the season, the thickness of the sod, the soil condition and characteristics at the time of disking, and the seeding practices anticipated. Seeding times employed included perennial species during August and September, February, March and April, and annual species in May and early June. The degree of kill depends upon the rate of application, the chemical employed, the amount of topgrowth on the sod at the time of spraying and the time of application.

In August seedings, weed seedlings have been troublesome. Weeds and regrowth in winter and spring seedings, particularly in winter small grains, have been less of a problem. Split applications of chemicals, primarily cacodylic acid, applied the same day as seeding has been effective in controlling weed competition in the new seedings. Attempts were made to evaluate the weed seed problem within the soil profile. Different degrees of tillage to regulate bringing weed seeds to the surface and subsequent germination had little influence on alleviating the weed problem.

Title: FORAGE INSECTS

Leader: R. S. Filmer

1. Study of root infesting insects of red clover: This study was initiated in 1956. Results of two years' work show that the clover root borer, Hylastinus obscurus, is present only in the northern counties of the state and seldom is numerous enough to be considered a major pest of red clover. Sitona hispidula and Sitona flavescens were found to be present in numbers in all red clover fields in New Jersey and to cause moderate to severe root injury. Fall and spring treatments of granular insecticides gave good control of Sitonids. Heptachlor and dieldrin granular materials at the rate of 1 pound of insecticide per acre gave the best control. Nematodes and root diseases were found to be present in seedling and second year fields. There appears to be some correlation between insect injury to the roots and root diseases.
2. Alfalfa weevil, Hypera postica life history and control studies: The alfalfa weevil is present throughout New Jersey and is generally controlled by spray applications of 4 ounces of heptachlor per acre. Two years' results with granular insecticides applied in the fall appear promising as an alternate control measure. Fall applications of granular dieldrin or heptachlor at 1 pound per acre have prevented egg deposition in the stems during the fall period, as well as low egg deposition and larval population during the early spring period. Migration of adult weevils from alfalfa fields during mid-summer has been noted with some injury reported on lima and snap beans. Sweep net collections in November and early December showed that weevils were present in numbers in alfalfa fields. Egg laying in stems can also be demonstrated in late November and early December.
3. Surveys in alfalfa fields in 1957 did not disclose the presence of the spotted alfalfa aphid, Pterocallidium sp., in New Jersey.
4. Populations of the meadow spittlebug, Philaenus leucophthalmus have been at a reduced level during the past two seasons. Statewide spraying of alfalfa for alfalfa weevil control may be responsible for this reduction in spittlebug populations.

Title: THE FEEDING VALUE OF HIGH NITROGEN GRASS PRODUCED BY HEAVY NITROGEN FERTILIZATION

Leaders: C. H. Ramage, C. Eby, R. E. Mather and E. F. Ogrinz

The following table summarizes the results of a feeding trial conducted during the winter of 1956-57 at the Dairy Research Station, Sussex, New Jersey. Just why the cows on the alfalfa ration produced more milk and the cows on high protein grass produced more weight gains is difficult to explain. Another feeding trial using similar hays is currently being conducted.

Summary of results of a feeding trial conducted during the winter of 1956-57 at the Dairy Research Farm, Sussex.

	Rations		
	Low Protein orchardgrass hay	High Protein orchardgrass hay	Alfalfa hay
4% FCM	28.55	28.52	30.47**
Hay D.M. consumed, daily lbs.	16.33**	17.55**	19.22**
Silage D.M. consumed, daily, lbs.	4.83	4.79	4.83
Hay equiv./100 lb. body wt., lbs.	1.96	2.18	2.37
Grain D.M. consumed, daily, lbs.	7.57	8.14	7.65
Grain/Milk ratio	3.77	3.50	3.98
Body weight gains, lb.	10.57	39.22**	3.45
TDN, based on requirements, %	60	58	55
TDN, calculated (Schneider)	57.6	65.0	57.7

**Differences significant at 1% level

Composition of hays fed

	Hay		
	Low Protein orchardgrass hay %	High Protein orchardgrass hay %	Alfalfa hay %
Dry matter	87.6	86.7	87.4
Crude protein	12.4	14.7	17.6
Crude fiber	33.4	29.0	30.3
Nitrogen-free extract	43.3	44.7	41.1
Ether extract	2.8	3.1	2.1
Ash	8.1	8.4	8.9
Calcium	0.7	0.5	1.1
Phosphorus	0.37	0.19	0.19
Manganese	0.0033	0.0088	0.0022
Lignin (protein-free)	8.48	7.68	7.62

Title: HORSE PASTURE RESEARCH

Leaders: R. W. Duell, M. A. Sprague and R. Marrese

Laboratory research disclosed that inadequacies in techniques of analysis of phytin are most probably the cause for conflicting reports on the availability of this organic phosphorus compound to plants and animals.

The promising performance of Midland bermudagrass, originally noted in nursery trials, has been substantiated by yields of 2-1/2 tons per acre during drought conditions in three areas in the state. During the season of its maximum growth, conventional grasses were quite unproductive. The extremely tough turf is an additional asset to its use in horse pastures.

Burnet yielded nearly as much as orchardgrass on a seasonal basis in nursery trials but was much more uniform in production and recovered rapidly even when clipped during drought conditions.

Yields of six commonly used forage grasses under 3 levels of fertility were not appreciably different in 1957, a droughty growing season, from those of 1956, a season with very good rainfall distribution. This lack of difference is due to the fact that the bulk of the seasonal yields is made from the first 2 (of the 4) cuttings which were made before soil moisture became limiting. Chemical analyses of plant material indicated that harvests accounted for an average net loss (above that added in fertilization) of 90 lb./A of K_2O and 60 lb./A of Ca from the soil and an accumulation of P_2O_5 in the order of 12 lb./A. Analyses of soil samples, however, gave no clear-cut differences in chemical constituents.

In seedling competition studies, the suppression of birdsfoot trefoil by alfalfa can be attributed to the aggressiveness of the latter, but the good stands of birdsfoot trefoil associated with tall fescue and the poor stands of this species with Kentucky bluegrass are not in keeping with the vigor of these species. Evidently other factors are operative.

Neburon and EPTC gave good selective weed control in alfalfa seedlings but were damaging to orchardgrass and brome grass seedlings. Dock was successfully controlled with fall applications of 2,4-DB without injury to seedlings of white clover, orchardgrass and Kentucky bluegrass.

Three hours of soaking in aqueous solutions of the sodium salt of gibberellic acid did not affect the subsequent germination of alfalfa nor birdsfoot trefoil over a wide range of concentrations and temperatures.

In Sudangrass and millet variety trials it was noted that all of the millets recovered from each of the several cuttings much better this past season than in three previous seasons. The reason is not apparent.

Title: PRESERVATION OF SURPLUS SPRING PASTURAGE IN PLASTIC MATERIALS
AS SILAGE

Leaders: M. A. Sprague, C. H. Reed and C. H. Ramage

Two 10-ton stacks of silage were preserved from excess pasturage in May and June and fed out during July to beef animals. Four feed bunkers on sleds were placed around each stack in turn, the top opened and the silage forked in- to the feeders three times daily. The placement of the feeders in the past- ure made the work light, reduced the wastage to nil, and served as barriers to keep the animals away from the stacks. A small stack of 6 to 7 tons of sorghum was ensiled in plastic for use of a small goat herd during the winter period. Very little if any silage is currently fed goats because of the difficulty in preservation of small quantities. These field trials tend to indicate the versatility of this method of preservation.

Present stacking methods of silage for covering with plastic are inadequate. Versatile reuseable forms are being designed and built for use experimentally in 1958.

NEW YORK (CORNELL UNIVERSITY)

Title: BREEDING AND CYTOGENETIC INVESTIGATIONS WITH THE FORAGE PLANTS OF
NEW YORK

Leaders: R. P. Murphy, R. E. Anderson, C. C. Lowe and J. W. Miller

Studies are in progress with alfalfa, birdsfoot trefoil, smooth brome grass, timothy and orchardgrass (1956 Annual Report, page 63).

Clonal evaluation nurseries were established for 549 alfalfa clones which have been screened from selection and breeding programs for the following characters: combining ability, common leaf spot resistance, wilt resistance and leafhopper tolerance.

Progenies of crosses between selected third-cycle clones of creeping rooted alfalfa are now undergoing field evaluation. Particular emphasis was placed on early expression of the creeping characteristic in selecting these clones. Two additional groups of third-cycle selections are being intercrossed dur- ing the winter of 1957-58; one group includes profusely creeping plants, the second is composed of very vigorous, erect growing plants with a limited ex- pression of the creeping habit. Progress is being made in recovering creeping plants with other desirable agronomic traits. Many progenies of the second- cycle selections showed the creeping rooted phenotype in frequencies above

80 percent when scored after two full years in the field; several progenies were all of the creeping habit. A high degree of expression for this character seems possible with repeated cycles of selection. Additional emphasis is being imposed on selections for increased seedling vigor in this material.

Second and third backcrosses for incorporation of wilt resistance into Narragansett and Flemish types are being evaluated in a previously wilt-infested field.

Ninety-six second-cycle bromegrass clones are being currently progeny tested for total yield and aftermath production. These were selected from synthetics and restricted polycross progenies of first-cycle clones. Polycross progeny tests have been planted for second-cycle selections made in timothy and orchardgrass. Clonal characteristics of these clones appear promising for further improvement in these species.

Crosses between artificially produced tetraploids of Lotus uliginosus and standard Lotus corniculatus have resulted in eight hybrid plants. Characteristics of both parents appear in the hybrids. One character, HCN reaction, which is lacking in L. uliginosus but strong in L. corniculatus is intermediate in the hybrids. Studies of compatibility relationships show both self- and cross-compatibility to be lower in the tetraploid plants of L. uliginosus than in diploids.

In a study of fertility in relation to chromosome behavior in smooth bromegrass it was found that open-pollinated fertility varied from 1.2 percent to 75.4 percent among a group of 60 selected clones. The exact somatic chromosome number was determined for 25 of these clones. Three clones had 54 regular chromosomes, 8 had 55, 12 had 56, 1 had 57, and 1 had 58. Fragment chromosomes were found in 4 of these clones and in 3 others for which the exact chromosome number was not determined. The euploids were more regular at meiosis in chromosome behavior and slightly higher in fertility than aneuploids. Clones without fragment chromosomes were found to be more regular at meiosis and slightly higher in fertility than clones with them. A number of lagging chromosomes at anaphase I cells in meiosis and the number of micronuclei at the spore quartet stage were negatively correlated with fertility at a very low level of significance. Percentage stainable pollen (aceto-carmin) varied from 69.2 percent to 99.7 percent and was not significantly correlated with fertility or any of the cytological observations.

Evaluation of the R_3 generation of bromegrass for radiation-induced variability is currently underway. The parent material was treated as dry seed with several dosage levels of fast neutrons. Variations noted in the R_1 and R_2 generations include thickened leaves, depth of green color, and numerous chlorophyll deficiencies expressed as white or yellow striping. One R_3 progeny is segregating for albinism.

Alfalfa seed treated with neutrons and with x-ray showed the expected increased seedling lethality at increasing doses. One unexpected observation was a decided stimulus to seedling growth at the x-ray treatment level of 40,000 r.

Title: BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO THE NORTHEAST. SUB-PROJECT I: BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO NEW YORK AND ADJACENT AREAS OF THE NORTHEAST

Leaders: C. C. Lowe, R. P. Murphy, R. E. Anderson, A. A. Johnson and F. C. Bent; and H. A. MacDonald (Agronomy) cooperating.

(Refer to 1956 Annual Report, page 64).

Testing was completed and results summarized for joint publication with the Nebraska Agricultural Experiment Station on the effect of advancing the seed generation of component parental combinations on the performance of the Syn. 1 generation of 4-clone (double-cross) synthetics. Definite evidence was obtained that seed generation of the parent lines did have an effect; the direction and degree of change varied with different synthetics. These results are at variance with those previously reported in corn. Lack of controlled pollination in alfalfa and compatibility relationships between specific clones are believed responsible.

Evaluation and checking of imported planting stocks of DuPuits alfalfa and of domestic seed lots tracing to them has continued and has revealed no evidence of any measurable change or variation in performance.

Studies are continuing on comparison of performance for the Syn. 1 vs. Syn. 2 seed generation of synthetics in brome grass, orchardgrass and timothy. There has been some change in performance (different synthetics vary) but the general evidence is that the degree of change is quite small compared to that observed in alfalfa synthetics.

Studies on the differential competitive effect of varieties within species are being concluded. Initial stand establishment of legumes was shown to be greatest when no grass or timothy was included in mixtures, intermediate with Lincoln brome grass, and least when the most aggressive brome variety, Saratoga, was used. Stand counts indicated competition occurred in late fall of the seeding year and spring of the first year of harvest. The most vigorous of alfalfa varieties, DuPuits, was least affected by companion grass competition and Ranger the most. Birdsfoot trefoil varieties were affected to a greater degree than alfalfa. Initial effect on legume stands was reflected in yields through 3 harvest years. Need for specific recommendations in matching improved varieties of legumes and grasses in mixtures is indicated.

Breeders seed plots are being maintained on five grass synthetics. Syn. 1 or Syn. 2 seed is also currently being produced on 10 other grass synthetics of promise. Breeding stocks of brome grass, orchardgrass and timothy are being maintained in clonal nurseries.

Studies are underway on effects of different types of cutting management and date of final cutting on varieties representing different growth types of alfalfa.

Title: STRAIN TESTING AND BREEDING OF FORAGE PLANTS FOR NEW YORK STATE AND VICINITY, WITH SPECIAL EMPHASIS ON PROBLEMS OF PRODUCTION DURING PERIODS OF MIDSUMMER DROUGHT

Leaders: C. C. Lowe, R. E. Anderson, R. P. Murphy, A. A. Johnson and S. B. White; and H. A. MacDonald (Agronomy) cooperating.

Past and current trials for determining performance of forage varieties and mixtures cover all of the important areas of agricultural production within the state (1956 Annual Report, page 65). Sites have been chosen to test performance under the cultural limitations of soil drainage, depth and fertility characteristic of the various areas.

Preliminary evaluation trials of varieties and synthetics now encompass, where at all possible, several cutting managements, fertility levels or associations. Studies recently completed on alfalfa conclusively show that interaction of cutting managements with varieties is of considerable magnitude and that more than one management is necessary to obtain a reliable comparison of the nature and size of production potentials.

Alfalfa: Since much of the increase in alfalfa acreage in New York is in areas considered marginal for production, successful stand establishment is of paramount importance in varieties used. Drainage and other soil limitations result in relatively short-lived stands so that high production in the early harvest years is essential.

Narragansett has consistently given the best performance under the above described conditions. Vernal gives equally good performance except where environment is unusually critical. There has been little difference between these varieties on good alfalfa soils; Narragansett has survived better under severe clipping stress and under marginal drainage conditions. Mixtures of Narragansett and Viking trefoil are proving extremely promising for areas of marginal and spotty drainage.

DuPuits consistently gives best performance of the Flemish strains tested. The use of this variety in short rotations under intensive cutting greatly increases the tonnage and hay quality potential for alfalfa on good land. Seedling vigor of this variety is very strong but survival under poor drainage is inferior to Narragansett and Vernal. Ranger is recommended but is less desirable than the other three varieties in the situations described.

Bromegrass: Saratoga is slightly higher in total yield and averages about 1/3 more aftermath than commonly used Southern-type varieties. Because of seedling competition it is less desirable than timothy as a companion grass for birdsfoot trefoil. It is a good companion grass for the new and vigorous alfalfa varieties. Bromegrass appears to be easily injured by frequent clipping when grown in mixture.

Red Clover: Recent trials have indicated severe yield losses due to northern anthracnose on susceptible varieties. General incidence and prevalence of this disease is difficult to determine. Pennscott and Commercial strains are susceptible, Dollard is somewhat resistant.

Timothy: Varieties with late maturity are desired because of better quality at time of harvest. Varieties one week later in maturity than Common such as Climax, have been found to yield equally well as Common. Varieties like Essex which are two weeks later than Common average .2 to .4 tons less in production capacity for the season. During the period from June 10 - July 10, dry matter content of the forage consistently indicates a quality differential in favor of later maturing varieties, although the quality of hay for all varieties changes rapidly during this period. Cutting early is strongly recommended for all varieties to improve quality of the first harvest and to increase the quantity of very valuable aftermath production. Good quality hay may be harvested from late maturing varieties over a longer period but at some sacrifice in season production. Essex is recommended where late cutting cannot be avoided. Climax is recommended wherever timothy is grown.

Orchardgrass: In orchardgrass, as in timothy, late-maturing varieties will give high quality forage for a longer period than early ones but at some sacrifice in season production potential because of a shorter effective growing season. The spring growth of late varieties can be more easily managed, however, which overcomes a major objection to this species. Rate of recovery and the competitive effect on companion legumes for the late types appear to be about the same as for Common. Late orchardgrass is in about the same maturity class as bromegrass. Tests are underway to determine differences in their performance under different managements and mixture associations.

Trials on methods for growing and establishment of improved grasses for seed production under New York conditions are underway. Fall seedings in rows without a companion grain crop or spring seedings with oats have given good results for improved varieties of timothy and bromegrass.

Title: BIRDSFOOT TREFOIL IMPROVEMENT, BREEDING AND STRAIN EVALUATION
(In cooperation with A.R.S.)

Leaders: H. A. MacDonald, R. R. Seaney, I. Pootschi and David Gershon

Progress: Many introductions, lines, sources and varieties of birdsfoot trefoil are under study. Particular attention and effort during the past year have been given to the evaluation of available material and the development of improved varieties for pasture and hay use. The inheritance of growth form and vigor is being studied using the widely different varieties, Viking, Empire, and Kent as source material. Attempts are being made to develop lines resistant to seed shattering.

Title: BIRDSFOOT TREFOIL SEED PRODUCTION

Leaders: H. A. MacDonald and Richard Shibbles

Progress: During the past year particular attention was devoted to grass and weed control in birdsfoot trefoil and to factors affecting seed quality. Studies on bud drop were continued as were studies relating to cultural and harvest practices.

Bud drop has been found to be due to several factors rather than to a single cause. Current studies include soil moisture, temperature, plant nutrition and insect control.

Seed production is largely limited by grass competition in mixed stands. The degree of competition has been found to be a function of grass height, density, leafiness and time of maximum development. The use of dalapon (2,2-Dichloropropionic acid) effectively controlled most grass species and the true clovers resulting in increased seed yield of higher purity.

Following the removal of grass from birdsfoot trefoil seed fields, and in fields lacking grass, broad-leaved weeds constitute a most serious problem. This is now under study.

Few samples of birdsfoot trefoil seed exceed 85 percent in total germination (P.L.S.). Studies have shown that this low figure is principally due to the presence of relatively large amounts of immature seed. Attempts are now being made to find a solution to this problem through breeding, culture and management.

Title: DISEASES OF FORAGE CROPS

Leaders: D. A. Roberts, R. E. Ford, J. M. Kainski, Evamarie Sandler
and C. H. Ward

Results obtained from inoculation experiments in which whole plants were inoculated in the field and in the greenhouse, and in which detached leaves were inoculated in the laboratory indicate that the detached-leaf technique is satisfactory for determining resistance or susceptibility of alfalfa clones to black stem caused by Phoma herbarum var. medicaginis.

A total of 2205 isolates was made from 173 diseased roots of Lotus corniculatus. Pathogenicity of 244 fungal isolates to Empire and Viking birdsfoot trefoil has been tested by the technique involving the use of sand-nutrient culture of seedlings in glass tumblers. Three isolates of Fusarium sp. and 2 of Rhizoctonia sp. completely inhibited germination of Lotus seed. Some of the fungi tested caused damping-off of seedlings, and others incited rot of young roots. Several isolates stimulated seedling growth. Fungi isolated from Lotus roots will be tested for pathogenicity to roots of older plants. A study will be made of the phenomenon of growth stimulation by several fungi that are associated with the rot of Lotus roots.

Evidence has been obtained that Stemphylium loti can gain ingress into leaves of Lotus by means of direct penetration, without forming an appressorium. This is not to imply that stomatal entry does not occur or that appressoria do not form. A histological study of incubational and infectional phenomena of Stemphylium disease of Lotus will be continued.

Approximately 50 introductions and species of Lotus have been tested for resistance to the Stemphylium disease. None was immune, but several were highly resistant. Resistant, moderately resistant, and susceptible plants have been kept for hybridization work.

Biological studies of red clover vein mosaic virus are being continued. Gomphrena globosa has proved to be a satisfactory local-lesion host for this purpose. Natural infection of Ladino clover by red clover vein mosaic virus was observed.

Over a 5-year period it was observed that black stem of alfalfa and northern anthracnose of red clover caused severe losses of first-harvest hay when rainfall in the preceding autumn had been adequate to insure abundant production of inoculum, when there was measurable rainfall during each of at least 18 days in May, and when mean temperatures were near or above normal in March, April, and May. Even when other conditions favored disease development, these 2 diseases caused but little damage if there were 17 or fewer days in May with measurable rainfall. Pseudopeziza leafspots of alfalfa and red clover were particularly mild when mean temperatures during March, April, and May were not more than 28°, 41°, and 51° F., respectively.

Title: BIRDSFOOT TREFOIL CULTURE AND MANAGEMENT FOR HAY, PASTURE, AND
SILAGE

Leaders: H. A. MacDonald and David Evans

Progress in 1957: During the past year major emphasis was given to the crop management phases of this study. Certain of the investigations previously reported were continued and new studies added.

Studies of the adaptation of birdsfoot trefoil to a variety of soil moisture situations were carried out throughout the State. Both high water table and periodic flooding are involved. To date the results indicate a considerable tolerance to high soil moisture condition in comparison to alfalfa.

The importance of controlled culture was clearly demonstrated in studies involving companion crops, fertilization and weed control. The omission of an oat companion crop resulted in a three-year average Empire hay yield of 3.20 tons compared to 2.45 tons when seeded with oats. For Viking birdsfoot trefoil the yields were 3.54 and 2.67 tons.

Weed competition may be equally as harmful as the companion crop. In a recent study the influence of plant nutrition and weed control on the establishment and production of Viking birdsfoot trefoil produced the following results:

Treatments	Fall		Hay
	Seeding	Vigor	Yield
			tons
Fertilized, 300 lbs. 8-16-16 weeds removed	100		3.20
" " weeds present	23		2.07
Not fertilized _____ weeds removed	28		1.34
" _____ weeds present	12		.96

Birdsfoot trefoil was found to be more tolerant of frequent harvest than alfalfa. When cut twice each year on a high lime soil, Ranger alfalfa was higher in yield than Viking birdsfoot trefoil, when harvested three times the yields were the same. Under four and five harvests, the yield of birdsfoot trefoil was higher than that of alfalfa and the stand was less injured. Decline in yield with increased harvest frequency was less marked where a high fertility level was maintained. Close harvest severely reduced subsequent forage yield root reserves and rate of recovery following harvest.

Title: FACTORS AFFECTING SEEDLING ESTABLISHMENT OF FORAGE CROPS

Leaders: H. A. MacDonald and David Henry

Progress: While many of the studies previously reported were continued during 1957, special consideration was given to seed quality, field management and plant competition as factors affecting seedling establishment.

In the case of alfalfa and birdsfoot trefoil and to some extent also timothy and brome grass, seed size, seed maturity and seed injury were found to be important factors in seedling establishment. Small, weak or injured seed, although showing fair to good laboratory germination were found to be quite inferior for field planting. The seedlings were retarded, weak, and many failed to emerge or soon died.

Clipping, grazing, trampling or other injury to the primary leaves of the young seedling greatly reduced seedling vigor and the resulting stand. Defoliation in the early stages reduced root development, top height, tillering and dry matter production in the first year.

Weed competition was found to be equally as serious as the use of a companion crop. The removal of the weeds in forage seedlings without causing injury to the seedling presents a real problem. Selective chemicals now under study offer real promise.

ENTOMOLOGY RESEARCH AT CORNELL UNIVERSITY

Alfalfa Snout Beetle Investigations: Three and 5 pounds per acre of dieldrin or heptachlor (actual toxicant) applied as granules were found to give good protection of stands of new alfalfa seedlings from attacks of the alfalfa snout beetle. Five pounds per acre of dieldrin gave complete protection and no larvae were found in these plots. Aldrin at these same dosages was less effective.

Potato Leafhopper Investigations: Both thiodan and phosdrin were found to be effective for leafhopper control on alfalfa. However, phosdrin at 0.25 pound per acre gave some phytotoxicity. Methoxychlor was found to be more effective and gave longer residual action than thiodan. Heptachlor when used up to 2 pounds per acre gave very poor control of the potato leafhopper.

Clover Root Borer Studies: The clover root borer was found to pass through a variable number of instars ranging from 3 to 6. Of 59 larvae, 6 percent passed through 3 instars, 80 percent through 4, 13 percent through 5, and 1 percent through 6 instars.

In a study of host preferences, neither alfalfa nor white sweet clover were found to be suitable hosts. Borers confined to such roots died without feeding.

Crowding of adult beetles had an adverse effect upon egg laying. Pairs of beetles confined separately laid an average of 1.7 eggs per week while only 0.2 eggs per week per female were laid where 5 pairs of adults were confined together.

In tests of new toxicants, neither sevin nor thiodan at 1 or 2 pounds per acre gave effective control of the borer.

Title: MEADOW SPITTLEBUG

Leaders: H. H. Shorey and George G. Gyrisco

Thiodan gave good control of the nymphs of the meadow spittlebug at dosages as low as 0.1 pounds per acre of actual toxicant. It was as effective as lindane at rates as low as 0.05 pounds per acre. Phosdrin compared to lindane at 0.25 pounds per acre of actual toxicant was not found to be as effective.

Title: EUROPEAN CHAFER STUDIES

Leaders: H. H. Shorey and George G. Gyrisco

Granulated aldrin and dieldrin reduced the numbers of European chafer larvae more than the same toxicants applied as emulsions. Both sevin and thiodan show promise for grub control and warrant further testing. After 7 years, chlordane at 8 pounds per acre was still giving nearly perfect control while parathion and BHC at the same dosage had lost their effectiveness. After 3 years, dieldrin applied as granules at 1 and 2 pounds per acre was still giving excellent protection of pasture sod. Results averaged over the years 1954 and 1957 indicate that isodrin at 0.5, 1 and 2 pounds, aldrin at 0.5 and 1 pound, and heptachlor at 0.5 and 1.0 pound per acre reduced the numbers of grubs below the level found in the untreated checks.

Title: THE RELATIONSHIP OF TIME OF CUTTING TO THE DIGESTIBILITY OF
DIFFERENT FORAGES

Leaders: J. T. Reid and K. L. Turk (Department of Animal Husbandry),
and W. K. Kennedy (Department of Agronomy)

The chief objective of this experiment is to study the influence of the time of cutting upon the digestibility of first-growth forages. During a ten-year period a study was made of 94 forages consisting largely of mixtures, but a few were grown as pure-species stands and fed either as silages or hays or as fresh, green forage. The relationship between harvesting time (X) in days after April 30 and percentage digestibility of the dry matter (Y) is expressed by the equation, $Y = 85.0 - 0.48X$. The standard error of estimate is 1.65%.

These studies are being extended to forages grown in various regions (therefore, at different elevations and latitudes) of New York State, and to forages grown under irrigation and various levels of fertilization.

Title: A COMPARISON OF DIFFERENT INTENSITIES OF GRAZING WITH GREEN-CROP FEEDING OF AN IMPROVED PASTURE MIXTURE

Leaders: J. T. Reid, K. L. Turk, G. W. Trimberger and M. J. Anderson
(Department of Animal Husbandry) and W. K. Kennedy, N. C. Brady
and H. A. MacDonald (Department of Agronomy)

Comparisons of the milk yield, forage intake, botanical composition and cost of production of an alfalfa-Ladino clover-brome grass mixture have been made during two seasons under the following management conditions: semi-continuous, rotational and strip grazing and the feeding of green, harvested forage.

Although the observations made to date are too few to allow definite conclusions to be drawn, it would appear that the yield of milk per cow is not greater for the feeding of green, harvested forage than for conventional grazing.

This project will be continued during three more seasons.

Title: THE DEVELOPMENT AND USE OF INDIRECT METHODS FOR THE MEASUREMENT OF DIGESTIBILITY AND RATE OF CONSUMPTION OF FEEDSTUFFS, PARTICULARLY PASTURE FORAGES, BY RUMINANTS

Leaders: J. T. Reid, K. L. Turk, M. J. Anderson, J. A. Holter and A. Bensadoun

During a nine-year period methods were devised for the measurement of the chemical composition, digestibility and intake of forage under grazing conditions and these methods were and are being tested under a variety of conditions.

In the interest of finding indicators which are easily measured and which might be applied to measure forage digestibility without requiring expensive equipment, a study was made during the past year of the use of nitrogen for this purpose. These studies indicate that the digestibility of forage protein conforms to a predictable pattern and that a knowledge of the protein (Total N x 6.25) concentration in the feces allows for reasonably accurate estimates of the forage digestibility. In addition, the percentage of digestible protein (Y) can be accurately predicted from a knowledge of the percentage of crude protein (X) in the forage according to the following equation: $Y = 0.929X - 3.48$, for which $Sy.X = 0.46$.

Studies were continued towards developing indirect calorimetric methods based upon the chemical composition of living animals for the purpose of evaluating forages in terms of net calories. Although the use of dilution techniques to measure the body composition of living animals is very promising, certain technical difficulties need to be overcome to make this procedure generally satisfactory.

Title: MAXIMUM UTILIZATION OF FORAGES BY LIVESTOCK

Leaders: S. T. Slack, K. L. Turk, G. W. Trimberger, J. I. Miller, J. T. Reid and J. K. Loosli (Department of Animal Husbandry) and W. K. Kennedy and H. A. MacDonald (Department of Agronomy)

These investigations were started in 1944 to study the effects of methods of harvesting and storing upon (a) the nutrient losses and chemical composition of forage and (b) upon the quality, digestibility and feeding value of forages for various classes of livestock. Further objectives have included studies on the effects of stage of maturity at harvesting upon feeding value and of high quality forage in reducing the need for concentrates.

When harvested at the same stage of maturity, no significant differences in feeding value have been obtained between barn-dried hay, field-cured hay, and hay-crop silage. More milk per acre has been produced from barn-dried hay and silage because of a greater proportion of nutrients preserved for feeding than from field-cured hay.

Early-cut barn-dried hay and silage (June 6-10) have produced significantly more milk (12-15 percent) than late-cut, field-cured hay (July 7-10). Significantly higher growth rates have been obtained in feeding trials with dairy calves and yearling heifers for early-cut compared with late-cut forages. These early-cut forages also have affected significant savings in amounts of grain being fed.

Trials are in progress with lactating cows to study further the potentials of early-cut forages in reducing the dependence upon concentrates. Also, tests are being conducted on the value of alfalfa pellets when fed with hay-crop silage and mixed hay in wintering rations for steer calves.

Title: NITRATE ACCUMULATION IN FORAGES

Leaders: R. F. Crawford and W. K. Kennedy

Species of cereals were different in their nitrate contents when grown under the same level of nitrogen nutrition in sand culture in the greenhouse. Likewise, varieties of oats in sand culture in the greenhouse and also in the field had significantly different nitrate contents. High nitrate varieties such as Garry oats contained about 1% more nitrate (on dry matter basis) than low nitrate varieties.

There were significant differences between a winter wheat variety and 4 spring wheat varieties but in general all varieties were much lower than oats. In addition, 3 winter and 3 spring barley varieties were grown in a field experiment and there were varietal differences in their nitrate contents. The barley varieties were higher in nitrates than the wheat but lower than oats. In the greenhouse, Pennsylvania synthetic orchardgrass was extremely low in nitrate while N. Y. Selection 49-107 contained 1% nitrate even when no nitrogen fertilizer was applied.

Oat plants grown in a field experiment at five levels of nitrogen were separated into plant parts and their nitrate contents determined. Leaves and stems were high in nitrates with stems being higher than leaves at maturity. Heads were consistently low in their nitrate content.

In field tests all of the species investigated decreased in their nitrate content (on a % dry matter basis) as the plants increased in maturity. However, when oats were grown in sand culture at a constant level of nitrogen throughout their life cycle the nitrate content remained nearly constant.

The nitrate content of the plant was directly proportional to the rate of nitrogen fertilization. It was found that nitrate content of Garry oats grown in a field experiment increased with increased nitrogen fertilizer even up to 800 lb. N/A. At young stages of growth 50 lb. N/A was sufficient to bring the nitrate content to near the toxic limit of 1% nitrate.

The time of nitrogen fertilizer application had no significant effect on the nitrate content of Garry oats grown in the field. The rate of nitrogen was the important factor, regardless of time of application.

Twelve nitrogen fertilizer carrier treatments were used on Garry oats at the rate of 100 lb. N/A. There were some significant differences in the nitrate contents of the oats at young stages of maturity but as the oats matured these differences were no longer detected.

Light intensity under field conditions of variation was found to have a significant influence on the nitrate content of Garry oats. A cloudy day caused the nitrate content to be 1% higher than the previous sunny day. Artificially decreasing light intensity also caused high amounts of nitrates to accumulate in Garry oats in a field experiment.

Title: EFFECT OF MOLYBDENUM UPON THE GROWTH AND DEVELOPMENT OF FORAGE LEGUMES ON NEW YORK SOILS

Leaders: W. M. Kliever and W. K. Kennedy

A greenhouse experiment is being conducted to study the response of alfalfa and birdsfoot trefoil on several New York soils to molybdenum applied alone and in combination with different increments of lime. The treatments are being evaluated in terms of dry matter production, total N and Mo content of the forage, and nodulation counts. Field experiments will be initiated with legumes on soils showing a response to molybdenum in the greenhouse.

Preliminary studies were conducted on several New York soils during the last two summers using alfalfa as an indicator crop. Mardin silt loam showed a response to molybdenum when applied with lime. Dry matter yields of pots treated with 2 tons of lime plus 5 ounces of sodium molybdate were approximately twice the yield of pots treated with 2 tons of lime alone. These results were also comparable to the yields obtained from pots treated with 4 to 6 tons of lime. Molybdenum applied alone showed very little response over check treatments.

Title: STORAGE OF MOIST GRAIN BY MEANS OF FUNGICIDES

Leaders: W. M. Kliewer and W. K. Kennedy

The deterioration of grain from molding when stored at too high a moisture content results each year in considerable economic loss. The use of fungicides to prevent mold growth when grain cannot be dried to a safe level in the field has recently been studied as a possible alternative method of storing grain.

About one-third of the 46 chemicals used in preliminary laboratory screening tests prevented the appearance of visible mold growth for 107 days at the rates tested. The chemicals which prevented mold growth when applied alone also were tested in combination. Of 112 different combinations of chemicals, only 22 were effective in preventing mold growth for 105 days. Many of these mixtures of compounds were effective only at heavy rates of application and did not warrant further testing.

Continued laboratory tests were conducted with the most effective fungicides on moist shelled corn. These were studied in two groups: chemicals applied alone and chemicals applied in combination. The chemicals most effective when applied alone were 2, 4, 6-trichlorophenol, 1(2,3)-chloro-4 methyl-2 pentanone, 1-chloro-2-butanone, ethyl 2, 3-dibromopropionate and methyl 2, 3-dibromopropionate. The first two chemicals controlled mold growth at a rate of application of 0.25% and the latter three at 0.30% for a period of 108 days. 2, 4, 6-trichlorophenol and 3, 5-dimethyltetrahydro-1, 3, 5, 2H-thiadiazine-2-thione both prevented mold growth when applied in combination with the above listed chemicals at rates as low as 0.20% for the mixture. A visible mold growth rating was closely correlated to total loss of dry matter and final percent moisture of the grain.

Several fungicides which had been effective under laboratory conditions were tested on 20-pound lots of wheat, ear corn, and shelled corn and stored in polyethylene bags. Trichlorophenol was the only chemical that consistently prevented molding in corn and wheat containing 24 to 28% moisture at rates of application of 0.30 to 0.40% for periods of storage up to 168 days.

The work to date indicates that safe storage of moist grain in the laboratory and in small scale field experiments by means of fungicides is possible. At the present time, it is not economically feasible as the cost of a suitable fungicide is not competitive with other methods of preserving grain.

Title: FOLIAR APPLICATIONS OF UREA ON FORAGE GRASSES AND THEIR EFFECT ON FEEDING VALUE

Leaders: Roger L. Mitchell and W. K. Kennedy

Preliminary studies were made in 1957 of foliar urea applications on timothy (late cut), timothy and reed canarygrass (aftermath) and oats, all cut for hay on field scale. No yields were taken of dry matter per acre, but nitrogen analyses of the forages gave only small increases over the check for nitrogen applications of 10-20 pounds per acre. These hays are currently being fed to sheep to determine any possible effects on digestibility of the foliar applications.

In addition, the effect of foliar urea applications on alfalfa-orchardgrass and orchardgrass-bromegrass swards cut in the vegetative stage was studied with small plots; the results are given in the following tables. Four cuts were made in both experiments and the nitrogen applied four times during the season.

Orchardgrass - bromegrass experiment (Figures listed are means)

Treatment	% N in forage	Yield tons/acre
Check	2.32	.8
Urea (Solid in soil-160#N) (a)	2.98	2.7
NH ₄ NO ₃ (Solid in soil-160#N (a)	2.85	3.1
Urea spray (160#N) (b)	3.47	2.1
Urea spray (320#N) (b)	3.72	3.4

(a) Solid applications made on same day as previous cut of forage.

(b) Spray applications made 20 days after cutting.

Alfalfa - orchardgrass experiment

Treatment	% N	Yield tons/acre
Check	3.03	1.4
Solid urea 160# N/A (applied on day of cutting)	3.52	2.8
Solid NH ₄ NO ₃ (160# N/A)	3.58	2.1
Urea spray - 0 days following cutting 160# N	3.55	2.8
Urea spray - 10 days " " 80# N	3.31	2.0
Urea spray - 10 days " " 160# N	3.57	2.4
Urea spray - 20 days " " 80# N	3.37	1.7
Urea spray - 20 days " " 160# N	3.52	2.3

For 1958, it is planned to utilize timothy and orchardgrass for feeding trials with sheep and steers. Each will be cut at two stages of growth and with 3 treatments each; check, urea applied solid to the soil and as a foliar spray. In addition, small plot work will be done on the effect of various rates of urea applied to the soil and to the leaves on % of N in harvested material, rate and % of uptake, yield effects on dry matter and protein, residual urea on the outside of leaves, and to check for any burning effects at high rates of N using low buiret urea.

PENNSYLVANIA

Title: THE GENETICS AND IMPROVEMENT OF ALFALFA (MEDICAGO SATIVA L.)

Leaders: H. R. Fortmann, R. W. Cleveland and J. L. Starling

The second years' results were obtained from alfalfa variety trials established at six locations in the state in 1955. Two additional trials were established, at Ligonier, Pa. and at Centre Hall, Pa. The trial at Ligonier will provide information appropriate for a region not covered by the earlier established trials. Results from these trials obtained in 1956 were published in Progress Report 180 (August 1957).

Clones collected by R. W. Cleveland in domestic exploration were preliminarily evaluated for breeding potential. Results from the forage species management study which includes three varieties of alfalfa requiring different management for maximum production were obtained. Two additional trials under this project were established at Tunkhannock and at Ligonier. This work is under the supervision of Mr. R. W. Cole, a graduate assistant.

Title: THE GENETICS AND IMPROVEMENT OF RED CLOVER

Leaders: H. R. Fortmann and R. W. Cleveland

A broadcast plot variety trial at University Park was harvested for forage yield in 1958. This experiment included five entries which were local farmer-grown strains of red clover collected in various parts of Pennsylvania, and also included three Swedish varieties originating from Weibull's Co. No variety or local strain tested was found to be superior to Pennscott.

Two new yield trials were established at Ligonier and Centre Hall, Pa. in 1957.

1956 data from yield trials at seven locations in Pennsylvania were published in Progress Report 180 (August 1957).

Work has proceeded in initiating a breeding program for resistance to northern anthracnose in red clover. A field planting of numerous strains of red clover was screened for resistant material after artificial inoculation with the organism. A satisfactory intensity of the disease was not produced for any assurance in selection. In continuing the search for material highly resistant to northern anthracnose, populations of Wisconsin synthetic red clover are being inoculated with the organism this winter under greenhouse conditions. Plants found to be resistant will be crossed to Pennscott red clover to initiate a backcross breeding system with the purpose of incorporating the gene or genes controlling resistance into the Pennscott variety. All disease investigations are in cooperation with Dr. Houston Couch (Department of Botany and Plant Pathology, PSU).

Title: THE GENETICS AND IMPROVEMENT OF BIRDSFOOT TREFOIL

Leaders: H. R. Fortmann, R. W. Cleveland and J. L. Starling

Trials established at six locations were harvested for the second year in 1957. Two new variety trials were planted at Ligonier and Centre Hall, Pa. in 1957. 1956 data from state wide variety trials were reported in Progress Report 180 (August 1957).

Seed was harvested from four experimental synthetics which were formulated and established in nurseries in 1956. Two synthetics are made up of "Empire-type" clones (late maturing pasture types) and two with "European-type" clones (early maturing hay or pasture types). The constitution of these synthetics was reported in the 1956 Annual Report, page 75.

Title: THE GENETICS AND IMPROVEMENT OF FORAGE GRASSES

Leaders: H. R. Fortmann, R. W. Cleveland and J. L. Starling

Pennsylvania Late Synthetic III was released by the Pennsylvania Agricultural Experiment Station in December 1957 under the name Pennlate orchardgrass. A ten-acre planting for the production of foundation seed was established in California under contract with Mr. Jack D. Jones of San Joaquin, Calif. The first crop should be produced in 1958. With good fortune there should be adequate seed available in the late summer of 1958 for allocation to seedsmen wishing to produce certified seed. A new nursery for the production of Pennlate breeder seed was established at Centre Hall, Pa. Over 300 replications of the parental clones were used in this planting.

Several other experimental synthetics of orchardgrass in various maturity classes have been formulated in recent years. Seed for testing purposes was harvested from all synthetics in 1957, and field test plots were established at University Park. At the present time, there are three early, three medium, and four late maturing experimental synthetics (excluding Pennlate) which were originated through work under this project. These synthetics are either being tested or will be entered in tests in 1958.

Yield of the polycross progeny of 136 orchardgrass clones selected in 1952 was measured. This polycross progeny trial was established at University Park in 1956.

Cytogenetic studies of hybrids between Phalaris arundinacea and Phalaris tuberosa:

Mr. J. L. Starling has continued studies of this hybrid in respect to its cytological behavior, and in addition has made parallel studies in the parental species. Results of the investigation will be submitted in the form of a Ph.D. thesis in the coming year. The ultimate goal of such studies is to assess the value of this hybrid as a basis of improving reed canarygrass.

Variety trials at seven locations in Pennsylvania were harvested for the second year in 1957. The 1956 results for orchardgrass, timothy, and smooth brome grass were published in Progress Report 180 (August 1957).

The performance of Pennlate orchardgrass in these trials was used as a basis for release of this variety by the Agricultural Experiment Station.

New field experiments designed to obtain critical information on the qualities of orchardgrass varieties and experimental synthetics were established at Tunkhannock and Ligonier, in northeastern and southwestern Pennsylvania respectively. A planting identical in design to these two had previously been made at University Park. One year's data were obtained in 1957 from the University Park planting. Mr. Richard Cole is in charge of these experiments as his graduate research problem.

Two new variety trials were established at Ligonier and Centre Hall, Pa.

Cooperative Regional evaluation of orchardgrass and smooth brome grass clones and progenies was continued in 1957. Results of these trials are summarized in the NE-28 report for 1957.

Title: THE INTRODUCTION AND EVALUATION OF FORAGE CROPS BREEDING STOCKS

Leaders: R. W. Cleveland and J. L. Starling

An observation nursery including over 900 accessions was established in 1957. This nursery includes primarily strains of forage grass and legume species which have been obtained from Plant Introduction Stations, but also includes strains from other domestic and foreign sources. A very limited preliminary evaluation of these materials was possible in 1957.

Title: FORAGE AND GRAIN PRODUCTION OF WINTER SMALL GRAINS AS INFLUENCED BY FERTILIZATION AND MANAGEMENT PRACTICES

Leaders: J. B. Washko and A. L. Haskins

Balbo and Tetra petkus ryes, Pennoll and Dual wheats, and Wong barley were compared under grazing conditions in the fall of 1956 and spring of 1957. The highest yielding variety for forage was Balbo rye. Approximately the same amount of forage was produced by the wheat and barley varieties. In the fall the Balbo rye had the greatest carrying capacity and the Dual wheat the lowest. The Wong barley had approximately the same fall carrying capacity as the two rye varieties. In the spring the two rye varieties had the greatest carrying capacity, then the two wheat varieties and the Wong barley the lowest.

After the last grazing in the spring the small grain stubble was plowed and a seedbed was prepared for seeding Piper sudangrass and pearl millet. These summer annuals were drilled-in for grazing with different rates of fertilizer applied with and without seed contact.

Pearl millet was more subject to fertilizer burning of the seed than Piper sudangrass. No injury to germination or subsequent forage yield was encountered with Piper sudangrass when 300 or 500 lbs. per acre of 5-10-10 fertilizer were drilled in contact with the seed. However, both of these fertilizer rates caused a reduction in stand and .7 tons of forage when drilled-in with Pearl millet seed. When 500 lbs. per acre of a 10-10-10 fertilizer were applied in contact with the seed both the Sudangrass and millet suffered injury from the applied fertilizer. Forage yields were reduced by approximately 1/2 ton of dried hay per acre for each species.

Title: RENOVATION OF UNPRODUCTIVE PASTURES

Leaders: J. B. Washko, R. R. Yoerger and J. K. Pasto

Four pasture renovation experiments were completed during 1957, two at University Park and one each at Wellsboro (Tioga Co.) and Dushore (Sullivan Co.). Five years' yield and other agronomic data have been obtained on one of the experiments at University Park and at Wellsboro, whereas three years' data are available on the other two experiments.

The value of pasture renovation for restoring pasture productivity is indicated by the following annual forage yields in tons per acre obtained with this pasture improvement method:

<u>Mixtures</u>	<u>University Park</u>	<u>Wellsboro</u>
Four Ladino clover - grass associations	1.71	1.39
Four Empire trefoil - grass associations	2.33	1.83
Four Viking trefoil - grass associations	2.70	2.45
Ky. bluegrass (check)	.93	.82

Viking birdsfoot trefoil in various grass associations continued to be the superior legume for pasture renovation conditions. Both varieties of trefoil, Viking and Empire, were longer lived and more productive of forage than Ladino clover.

Three years' data comparing seeding mixtures, renovation practices and initial fertility levels at University Park and Dushore indicate the following: at University Park yield differences between seeding mixtures and between initial fertility levels were not significant. In this experiment, however, seedbed preparation with the moldboard plow and heavy cutaway disk resulted in somewhat better forage production than when prepared with other tillage implements. In the Dushore experiment, seedbed preparation practices failed to influence forage production. Initial fertilization practices and seeding mixtures in this experiment did influence forage yields. A fertilizer application of 400 lbs. per acre of an 0-20-20 at time of seedbed preparation increased forage production more than an application of 400 lbs. of 20% superphosphate plus 300 lbs. of 5-10-10 per acre. At Dushore an association of Ladino clover and reed canarygrass produced the highest forage yields, whereas Empire birdsfoot trefoil with either timothy or reed canarygrass was next highest yielding.

In Potter County the following average forage yields were obtained over a 4-year period as a result of renovation: check .96 tons, Ladino clover-orchardgrass 1.33, and birdsfoot trefoil-timothy 2.35 tons per acre respectively.

Title: STOCKPILING OF FORAGE ON RENOVATED PASTURE

Leaders: J. B. Washko and D. A. Mays

In the spring of 1957, an experiment was initiated to investigate the feasibility of stockpiling forage. The term stockpiling as applied to forage refers to the practice of allowing forage to accumulate uncut in the field until it is needed for grazing. This practice has been suggested as a way of alleviating mid-summer pasture shortages.

The stockpiling experiments were established at two locations at University Park by fencing established pastures of Ladino clover-grass associations and birdsfoot trefoil-grass associations into small paddocks.

The following six management practices were compared in the experiment:

1. Grazed in rotation 3 times at pasture stage (10 to 12 inches),
2. Cut twice at hay stage,
3. Stockpiled until July 1 then grazed,
4. Stockpiled until July 15 then grazed,
5. Stockpiled until August 1 then grazed, and
6. Stockpiled until August 15 then grazed

One experiment was grazed by dairy cows and the other by beef cows. Each paddock was sampled for yield and percentage composition of crude protein and crude fibre before being grazed or cut for hay.

Stockpiling until July 1 and July 15 resulted in the greatest total forage yields, whereas the lowest forage yields resulted from stockpiling until August 1 and August 15.

Forage utilization was best under hay and rotation pasture management and was progressively poorer with the later dates of stockpiling. Only 25% of the forage was utilized when it was stockpiled until August 15.

Quality as determined by chemical analysis decreased as the season progressed as follows: protein content ranged from an average of 15.17% at the May 23 grazing to 7.20% at the August 15 grazing; crude fibre content ranged from an average of 28.14% at the May 23 grazing to an average of 35.76% at the August 15 grazing.

Title: FORAGE INSECTS

Leader: Norris D. Blackburn

Research efforts were again concentrated on the alfalfa weevil which continued to spread westward into 10 additional counties of the State during 1957. This makes a total of at least 35 counties in which it is known to occur.

Except for one or two coccinellids and a carabid predator, the alfalfa weevil does not appear to be adversely affected by any major biotic agency at the present time in Pennsylvania. No parasitoids, in particular, appear to have become established in the larval population.

A series of experiments was designed to compare the relative effectiveness of several granulated and emulsifiable materials each applied at the same rate in early spring for protection of the first crop of alfalfa against weevil damage. Such early-season applications of insecticides to forage crops, before new growth has developed significantly, eliminates or reduces to a minimum the danger from residues on the hay at harvest. Four granulated insecticides, aldrin, endrin, dieldrin, and heptachlor were applied at the rates of 1.5, 1.0, and 0.75 pounds of active material per acre while toxaphene was applied at the rates of 3, 4, and 5 pounds per acre. Only two emulsifiable concentrates, toxaphene and heptachlor, were applied for comparison. Data on larval abundance were obtained at two points in the population development during the period covered by the experiment. The last record was taken approximately 10 days prior to harvest of the first crop.

Records taken 21 and 32 days after treatment showed that toxaphene (both granulated and emulsifiable), aldrin, and endrin were relatively ineffective in reducing larval population levels even at the highest application rates employed.

Granulated heptachlor at the rate of 0.75 pounds per acre maintained a control level of approximately 98% compared with a control level of 91% maintained by an equivalent dosage of heptachlor emulsifiable concentrate applied at the same time.

Granulated dieldrin at the rate of 1.5 pounds per acre was almost as effective as heptachlor, but probably could not compete with it from a cost standpoint.

No data were obtained on the effects of these materials on other components of the forage insect complex.

Title: EVALUATION OF GRASSES AND LEGUMES FOR HAY, GRASS SILAGE, AND PASTURE FOR DAIRY COWS

Leaders: P. S. Williams, J. B. Washko and A. L. Haskins

Since the legumes in the grass-legume associations under grazing had dropped below 20% by the spring of 1957, this experiment was modified somewhat from that of former years. Two split applications of 45 lbs. of nitrogen in the form of urea were applied after the first and third grazings respectively on three of the associations; namely S-37 orchardgrass-Buffalo alfalfa, Kentucky bluegrass-Empire trefoil and S-37 orchardgrass-Empire trefoil. The tall oat-grass and reed canarygrass-trefoil paddocks were plowed in the spring of 1957 and re-seeded to Piper sudangrass and Pearl millet because of stand losses of the seeded species and invasion by weeds and other contaminants.

The S-37 orchardgrass-alfalfa association with nitrogen continued to be the most productive mixture of the perennial species and the Kentucky bluegrass-trefoil combination was next highest yielding. Yield increases for 90 lbs. of nitrogen per acre were as follows: 1.15 tons for the S-37 orchardgrass-alfalfa mixture, .82 tons for the Kentucky bluegrass-trefoil and only .47 tons for the S-37 orchardgrass-trefoil association. The Sudangrass produced 4.11 tons of dry matter and the pearl millet 4.39 tons in 4 rotational grazings with the nitrogen fertilization. Pearl millet responded better to nitrogen topdressing than did the Sudangrass.

This combination of perennial and annual species gave better and more uniform forage distribution during the grazing season than did the perennial species in other years despite the severe summer drought of 1957. Forage for rotational grazing was available every week from May 10 to October 1, except the last week in August and third week of September.

Title: UTILIZATION OF FORAGE BY BEEF CATTLE

Leaders: E. F. Sullivan, J. B. Washko, G. A. Kean, R. C. Miller, J. K. Pasto and A. L. Haskins (with cooperation of Rockview Branch of Pennsylvania Department of Penal Institutions)

Second year results were obtained from an experiment designed to evaluate 4 systems of forage utilization by beef cattle on rotation pasture. In addition, a dry lot system was included. The effects of pasturage with and without legume, grain feeding on pasture, and diethylstilbestrol implantation were indicated as follows:

(1) Cattle grazing nitrogen fertilized (116 lbs. per acre) grass pasture produced 143 lbs. of liveweight gain per acre as contrasted to 166 lbs. obtained from legume-grass pasture.

(2) The feeding of concentrates increased the rate of gain of cattle grazing grass (25 lbs. per acre) but had no effect on cattle grazing legume-grass pasture.

(3) Diethylstilbestrol (24 mg. per steer) increased the rate of gain of cattle on all pasture with (31 lbs. per acre) or without (21 lbs. per acre) grain feeding.

(4) Animal finish as reflected by carcass grade was not influenced appreciably by pasture type, grain feeding, or by stilbestrol. Average grade of all animals off pasture was high standard. However, carcass dressing percentage was increased by 6% by grain feeding on pasture but not by pasture type or stilbestrol.

(5) Cattle having access to dry lot feed continuously gave slightly higher liveweight increases than cattle having access to pasture herbage.

Title: AN ECONOMIC EVALUATION OF PASTURE IMPROVEMENT AND PASTURE RENOVATION

Leaders: J. K. Pasto and J. B. Washko

The previous two years of work have been confined to objective three of the State Contributing project. This work dealt with determining a technique for estimating pasture production. This year's work has been confined to objectives one and two of the State Contributing project. These objectives deal with determination of physical inputs, costs, returns and conditions under which pasture renovation and/or improvement may be desirable.

The following has been done during the calendar year toward accomplishing our objectives:

(a) Eight dairy farms in three counties in Northeastern Pennsylvania have been selected as a basis for this phase of the study. These farms have been selected as being representative of dairy farms in the Tioga-Bradford Upland of Pennsylvania. Rather complete information has been obtained on these farms. SCS Soil maps have been obtained and soil tests have been taken on each farm. Data were also obtained on types of crops raised, cropping practices, estimated labor requirements for crop operations, numbers of livestock, amount of labor available for farm operations, type and amount of machinery, and available building space for various types of livestock and crops.

(b) Yield data from experimental plots in the area on improved and renovated pastures have been provided by the agronomists. These yields are based mainly on 5 years of continuous experimental work on various farms. Yield estimates for other crops and fertilizer requirements are being provided by the agronomists.

(c) Input requirements such as labor, feed, and space have been collected from numerous sources and coefficients estimated for the farms considered. Estimates of land clearing costs have been collected from individuals doing custom work of this type in the area. Prices of other inputs and the prices of products have been determined based mainly on 1956-57 prices for that portion of the state.

(d) Initial budgets for the analysis are being set up on basis of two levels of difficulty for renovation including (1) land that contains little or no brush or rocks and (2) land which has up to 50 percent coverage with briars, brush or rocks, and (3) also, improved permanent pasture vectors are being included as processes in the budgeting (linear programming) model.

Usefulness of Findings: This phase of the analysis is not far enough along to make specific application of results at this date.

Work Planned for Next Year: During the remainder of 1958, the budgetary analysis will be completed for the farms indicated above. Solutions to the budgets will be analyzed to determine the conditions under which renovation and improvement will be profitable. Consideration will be given to various labor and capital levels, yields and prices of products to determine their effects on renovation and/or improvement.

RHODE ISLAND

Title: NITROGEN FERTILIZERS FOR GRASS AND GRASS-LEGUME FORAGE MIXTURES

Leaders: R. C. Wakefield, J. W. Cobble and J. B. Smith

Plots of S-37 orchardgrass, Lincoln brome-grass and mixtures of each with Ladino clover were fertilized with two sources of nitrogen (inorganic and organic) at three times and three rates of application.

The 1957 season was extremely dry. Yields ranged from 0.71 tons to 4.20 tons of dry matter per acre. Highest yields were obtained with the Ladino clover-grass mixtures. Orchardgrass gave a greater response than brome-grass to equivalent applications of nitrogen. Ammonium nitrate was superior to ureaform in dry matter production, percentage of N in the dry matter and efficiency of N utilization. Two applications of nitrogen were superior to one application or three applications at the same yearly rate. Single applications resulted in highest yields at the first harvest but lowest yields for the year. Both fertilizer materials were similar in this latter respect.

When nitrogen was applied to grasses alone a rate in excess of 150 lbs. per acre was required to equal the dry matter yield of the clover-grass mixtures.

Title: BREEDING AND EVALUATING ALFALFA FOR EASTERN UNITED STATES

Leaders: T. E. Odland and R. C. Wakefield

A new plot of Narragansett breeder seed was established in 1956 and is now in production. A total of 37 pounds of breeder seed was produced in 1957. Another 1000 cuttings from the 1946 breeder seed plot were made and will be used to increase the new breeder seed plot. With the Registered seed class for Narragansett reestablished, the breeder seed plot should now be able to provide sufficient seed to keep the Certified seed program of Narragansett up to requirements.

Title: FORAGE CROP ESTABLISHMENT STUDIES

Leaders: R. C. Wakefield and R. J. Hull

This project is concerned with (1) the evaluation of band placement of fertilizer and legume seed, and (2) the use of chemicals for weed control in forage seedings.

During the extremely dry 1957 season, band placement of alfalfa seed was much superior to broadcast methods in terms of plant numbers and root development. Band seeding resulted in a 64 percent increase in seedling establishment while band seeding plus post-emergence chemical weed control resulted in a 93 percent increase in seedling establishment over broadcast methods. Response to fertilizers showed that phosphorus gave best results, although placement of seed was more important than the kind or amount of fertilizer used.

Several pre-emergence and post-emergence herbicides gave excellent weed control in seedling alfalfa, birdsfoot trefoil and Ladino clover. Neburon (2 lbs. per acre) and Eptam (4 lbs. per acre) were promising for pre-emergence use although residual activity was limiting. A combination of Dalapon (4 lbs. per acre) plus 4(2,4-DB) (1-1/2 lbs. per acre) applied post-emergence gave excellent control of both broadleaf and grass weeds with no injury to legumes. Harvest of legumes was virtually weed-free during the year of establishment when this combination of chemicals was used.

Title: INVESTIGATION OF NEMATODES ASSOCIATED WITH ALFALFA IN RHODE ISLAND

Leader: G. J. Stessel

Five- and six-year old alfalfa variety plots at Kingston affected by crown and root rots were found to contain high populations of Pratylenchus pratensis in 1956 and 1957. Pratylenchus sp. multiplied 4-fold within a 7-month period in greenhouse pot tests of Narragansett and Buffalo varieties in 1956-57. In 1957, a survey of alfalfa in 3 of the 5 Rhode Island counties, Pratylenchus sp. was encountered in all fields sampled. Studies on the effect of nematocides on emergence and persistence of alfalfa in small plots are in progress.

VERMONT

Title: EFFECT OF SIMULATED PASTURE MANAGEMENT PRACTICES ON THE PERSISTENCE, QUALITY, AND YIELD OF SEVERAL BIRDSFOOT TREFOIL SPECIES AND VARIETIES

Leaders: G. M. Wood and K. E. Varney

First year data on a heavy soil for this experiment (1956 Annual Report, page 92) was obtained in 1957. The following varieties, strains, and hybrids are now included in the test: Mansfield, Viking, Empire, Oregon narrowleaf, polyploid narrowleaf, and hybrids narrowleaf X European and narrowleaf X Empire. No significant differences in yields were obtained when trefoils were subjected to the so-called "severe" treatment (cut 5/22, 6/21, 7/24, and 9/6). Under the "rotational" treatment (cut 6/13, 7/19, and 9/6) Viking and narrowleaf X European yielded significantly higher than Empire, polyploid narrowleaf and Oregon narrowleaf, but not Mansfield and narrowleaf X Empire. When subject to the "aftermath" treatment (cut 6/24, 8/1, and 9/6) all trefoils performed essentially the same except Oregon narrowleaf which yielded significantly lower than Mansfield, Viking and the two hybrids. As the severity of the "grazing" treatment increased a significant decrease in average yields was found.

Title: FORAGE CROP INSECTS, THEIR RELATIVE IMPORTANCE AND CONTROL

Leader: G. B. MacCollom

Two years' data on the effect of insects on birdsfoot trefoil seed production continued to show a serious reduction in seed yields. Results obtained were similar to those reported in 1956 (1956 Annual Report, page 93).

Pollination studies were made in 1957 to determine the honeybee Apis mellifera (L.) population at varying distances from a single bee yard. One or more bees per square yard were present as far as 1,600 ft. from the hives during peak bloom, 1,600 ft. being the farthest distance bees had to travel to work the flowers.

Completion of a state-wide survey of clover root borer, Hylastinus obscurus (Marsham), indicates that this insect is not the prime factor in the poor persistence of red clover.

Title: THE USE OF BIRDSFOOT TREFOIL MEAL AS A CONSTITUENT OF POULTRY RATIONS

Leaders: G. M. Wood, R. T. Smith and D. C. Henderson

Trials with battery reared White Rock chicks have been conducted comparing the use of trefoil and alfalfa meals as feed constituents. In the tests carried out so far, birds fed the rations containing the trefoil meal have gained slightly less (although not significantly) than those fed rations containing alfalfa meal. The trefoil meal used was prepared by grinding excellent quality heat-cured trefoil hay. The alfalfa meal used was commercially prepared 17% dehydrated meal. Despite differences in preparation, feed constituents in each meal, as determined by chemical analysis, were similar. Further tests are planned using dehydrated trefoil meal.

Title: CONSUMPTION AND UTILIZATION OF FORAGE BY CHICKENS

Leaders: G. M. Wood, R. T. Smith and D. C. Henderson

Studies comparing range and confinement reared pullets were continued in 1957 (1956 Annual Report, page 92). Birds on 4 ranges (Kentucky bluegrass, orchardgrass, brome grass, Ladino clover) were compared with each other and with those reared in confinement. In order to encourage foraging the range birds were fed 10 percent less feed than the confined ones.

During the rearing period pullets from each range were slaughtered at biweekly intervals and post mortem analyses of crop contents made to determine amounts and kinds of forage consumed. Forage consumption (dry weight basis) on the grass ranges fluctuated throughout the rearing period between 0.7 and 4.0 percent. On the clover range, consumption of forage increased steadily throughout the ranging period to a maximum of 8.1 percent. Trap nesting records are now being taken to determine intensity and persistence of production. Egg shell quality was observed to be superior in the range reared groups.

WEST VIRGINIA

Title: SMOOTH BROMEGRASS VARIETIES FOR WEST VIRGINIA

Leaders: O. J. Burger and F. W. Glover, Jr.

Eleven varieties of smooth brome grass, Bromus inermis L., were seeded at five locations in West Virginia in the spring and summer of 1951. The variety names and the yield in tons dry matter per acre of these varieties grown with alfalfa and Ladino clover and percent contribution of smooth brome grass fraction to yield of the mixture are given in the following table.

Variety	Smooth Brome grass Plus Legumes		Smooth Brome grass Fraction		Percent Fraction of Total	
	Tons/A	Rank	Tons/A	Rank	%	Rank
Achenbach	2.46	5	1.22	3	52	1
Elsberry	2.43	6	1.23	2	50	3
Fischer	2.54	3	1.25	1	51	2
Lancaster	2.38	9	.88	9	39	9
Lincoln	2.51	4	1.18	5	49	4
Lyon	2.39	8	1.04	7	46	6
Manchar	2.42	7	.93	8	40	8
Martin	2.33	10	.77	10	36	10
North Commercial	2.14	11	.72	11	33	11
Oklahoma No. 1	2.57	2	1.13	6	45	7
Southland	2.58	1	1.19	4	48	5
Average	2.43		1.05		44	

Southern varieties produced consistently higher yields than intermediate or northern varieties.

Achenbach, Elsberry, Fischer, Lincoln, Oklahoma No. 1 and Southland were high producing southern varieties.

Title: ALFALFA VARIETIES

Leader: O. J. Burger

Several varieties of alfalfa were grown in rows. This seeding made in 1954 included varieties of Narragansett, Williamsburg, Atlantic, Vernal and others (1956 Annual Report, page 93). Atlantic, Rhizoma, and Williamsburg outyielded varieties such as Narragansett and Vernal. The yield of Atlantic was significantly higher than that of Vernal or Narragansett. Atlantic alfalfa at this one location at Morgantown was the highest yielding variety over the three-year period since the seeding of this test. The yield in tons dry matter per acre of Atlantic for three cuttings in 1957 was 3.37. The yield of Narragansett was 3.02, for Vernal 3.16, and for Williamsburg 3.19. Rhizoma continued its high yielding performance with 3.39 tons per acre.

Title: THE INFLUENCE OF FERTILITY AND MANAGEMENT ON SEVERAL LADINO CLOVER-GRASS MIXTURES

Leaders: O. J. Burger, C. B. Sperow and D. R. Browning

Description of treatments is given in 1956 Annual Report, page 94. The yields in pounds dry matter per acre of Ladino clover plus grass, the Ladino fraction and percent of the Ladino fraction of total for 1957 are given below: (Average of 5 Ladino clover-grass mixtures, 4 cuts, 4 replications on Wheeling fine sandy loam).

Treatment	Ladino Clover plus Grass lbs.	Ladino Clover Fraction lbs.	Ladino Clover %
0-0-0	1888	193	10
0-80-0	1787	160	9
0-80-80	2460	530	22
0-160-0	1879	117	6
0-0-160	2406	411	17
0-160-160 + 0-0-160 after first cut	2968	485	16
80-160-320	3710	378	10

Severe drought prevailed over most of the growing season. Rainfall from June until September during 1957 was only about three inches. The Ladino clover fraction yield was highest under the 0-80-80 treatment. Highest yield was obtained by application of 80-160-320 although the percent of Ladino clover fraction was quite low for this treatment.

Title: NITROGEN APPLICATION ON BLUEGRASS

Leaders: G. G. Pohlman and N. M. Baughman

ANL containing 20.5% nitrogen was applied to bluegrass sod at rates of 60, 120, 240, and 360 pounds per acre on April 10, May 28, July 1, and August 16, 1957. Maximum production was secured during April on the plots without nitrogen and on most of the plots receiving only 60 pounds of nitrogen. At higher rates maximum production was usually secured the month after application. Maximum production was in May for the plots treated with 120 or more pounds of nitrogen on April 10; in June for the 120 pound application made May 28; in July for the 240 and 360 pound applications made May 28, and for the 120-pound application made July 1; and in August for the 240- and 360-pound applications made July 1. Heavy applications of nitrogen in August caused severe burning and reduction in yield. All yields were low in the latter part of the season because of severe drouth.

LIST OF PUBLICATIONS

- Balch, C. C., J. T. Reid and J. W. Stroud. Factors influencing the rate of excretion of administered chromium sesquioxide by steers. Brit. Jour. Nutrition, 11:184-197. 1957.
- Battle, W. R. Atlantic alfalfa. New Jersey Agr. Expt. Sta. Bul. 787. 1957.
- _____. Making the most of red clover. New Jersey Agr. Expt. Sta. Circ. 582. 1957.
- Baylor, J. E. Establishment and early plant development of birdsfoot trefoil (Lotus corniculatus L.) as affected by several factors of competition. Ph.D. Thesis. The Pennsylvania State Univ. 1957.
- Blackburn, Norris D. Effects of some insecticidal materials on larval populations of the alfalfa weevil in southern Pennsylvania. Jour. Econ. Ent. 50(5):559-62. 1957.
- Blanc, M. L. The effect of climatic variables on evapotranspiration from forage crops. M.S. Thesis. Univ. of Maryland. 1957.
- Braverman, S. W. The physiology and pathogenicity of *Helminthosporium* species on forage crops. Ph.D. Thesis. The Pennsylvania State Univ. 1957.
- Brown, B. A. Soil liming experiments. Storrs (Conn.) Agr. Expt. Sta. INF-34. 1952.
- _____. Potassium fertilization of Ladino clover. Agron. Jour. 49:477-480. 1957.
- _____ and R. I. Munsell. Alfalfa varieties and seed mixtures. Storrs (Conn.) Agr. Expt. Sta. Bul. 258. 1947.
- _____ and _____. Small grains for fall pasture. Storrs (Conn.) Agr. Expt. Sta. Bul. 294. 1952.
- _____ and _____. Effects of cutting systems on Ladino clover. Storrs (Conn.) Agr. Expt. Sta. Bul. 313. 1956.
- _____ and _____. Clovers in permanent grassland as influenced by fertilization. Storrs (Conn.) Agr. Expt. Sta. Bul. 329. 1956.
- _____, _____, R. F. Holt and A. V. King. Soil reactions at various depths as influenced by time since application and amounts of limestone. Soil Sci. Soc. Amer. Proc. 20, 4:518-522. 1956.
- _____, _____ and A. V. King. Potassium and boron fertilization of alfalfa on a few Connecticut soils. Soil Sci. Soc. Amer. Proc. 10:134-140. 1945.

- Cobble, J. W. and B. W. Henderson. More milk and more cows per acre. Rhode Island Agriculture 3:4. 1957.
- Cleveland, R. W. Pennlate orchardgrass, a new late maturing variety. Science for the Farmer, Vol. 5, No. 3, Winter 1957-58.
- Colovos, N. F., H. A. Keener and H. A. Davis. Errors in drying silage and feces for protein and energy determinations. Improved procedures. J. Dairy Sci. 40:173. 1957.
- Decker, Jr., A. M., R. C. Leffel, C. P. Ellington, J. L. Newcomer and R. E. Wagner. Chesapeake - a new red clover variety. Maryland Agr. Expt. Sta. Bul. 462. 1957.
- _____ and T. S. Ronningen. Heaving in forage stands and in bare ground. Agron. Jour. 49:412-415. 1957.
- Evans, W. G., H. H. Neunzig, George G. Gyrisco and Roy G. Richmond. Aerial applications of granulated dieldrin for control of larvae of European chafer on hilly meadows and pastures. Jour. Econ. Ent. 50(3):273-276. 1957.
- Fortier, Rene and I. F. Fellows. Economics of forage production and utilization. Part I. Present patterns of production and utilization of forage crops in seven selected dairy areas. Northeast Regional Publication No. 31. December, 1957.
- Fortmann, H. R., R. W. Cleveland, J. L. Starling, R. H. Cole and A. F. Cook. Forage crop varieties in Pennsylvania Progress Report 180, August 1957.
- Garrison, C. S. In alfalfa seed what's the best buy? What's New in Crops and Soils, Vol. 10, No. 3. December 1957.
- Gordon, C. H. and J. R. McCalmont. The improvement of forage preservation in bunkers and stacks through the use of temporary seals. ARS 52-55.
- Graham, J. H. A Stemphylium disease of Ladino white clover. Phytopath. 47: 213-215. 1957.
- _____, V. G. Sprague and R. R. Robinson. Damping-off of Ladino clover and Lespedeza as affected by temperature and soil moisture. Phytopath. 47:182-185. 1957.
- _____ and K. E. Zeiders. Diseases of crown vetch. Plant Dis. Repr. 41: 925. 1957.
- Gyrisco, George G. Spittlebugs - how to control them. Am. Agriculturist 154 (9):11. 1957.

- Gyrisco, George G. Let's keep alfalfa king. Am. Agriculturist 154(8):14. 1957.
- _____. Alfalfa weevil spreading in East. Am. Agriculturist 154(14):6. 1957.
- Henderson, B. W., J. W. Cobble and H. J. Cook. Silage feeding of dairy cattle. Rhode Island Agr. Expt. Sta. Bul. 336. 1957.
- Hill, Helen D. and H. L. Carnahan. Karyology of natural 4X, 6X and 8X progenies of a tetraploid (4X) clone of Bromus inermis Leyss. Agron. Jour. 49:449-452. 1957.
- Johnson, A. A. and H. R. Fortmann. Usage of seed of improved forage crop varieties in the northeast. Penna. Progress Report 177, August 1957.
- Jutras, P. J. Save time and labor in handling baled hay. Maine Farm Research April 1957.
- _____. An analysis of the methods and equipment used in handling baled hay in the northeast. M.S. Thesis. Univ. of Maine. 1957.
- Kearney, P. C. An evaluation of pearl millet, Sudangrass, sorghum and corn for silage in Maryland. M.S. Thesis. Univ. of Maryland. 1957.
- Kennedy, W. K. Results of silage investigations with high protein, unwilted forage at the New York State College of Agriculture. Proc. 18th Conf. N. Z. Grassland Assoc. pp. 155-160. 1956.
- _____. Pasture improvement and management. Cornell Ext. Bul. 979. 1957.
- _____. and R. J. Lancaster. Comparison of faecal pigments and faecal nitrogen for the estimation of feed-to-faeces ratio of pasture fed cattle. Proc. N.Z. Soc. An. Prod. 17:56-62. 1957.
- Kerkin, A. J., Jr. The effectiveness of several new herbicides on the establishment of alfalfa and birdsfoot trefoil. M.S. Thesis. Univ. of Connecticut. 1957.
- _____. and R. A. Peters. Herbicidal effectiveness of 2,4-DB, MCPB, neburon and other materials as measured by weed control and yields of seedling alfalfa and birdsfoot trefoil. Proc. NEWCC 11:128-138. 1957.
- Kjelgaard, W. L. Tiered duct hay drying systems. Vol. 2, No. 4. 1956-57 Winter issue. Hay Drying News.
- _____. Good hay - no matter what the weather. Rural New Yorker, June 15, 1957.

- Kjelgaard, W. L. and P. M. Anderson. Tiered duct hay drying. Electricity on the Farm, June-July, 1957.
- Koehler, C. S. and George G. Gyrisco. The systemic action of lindane in alfalfa upon the meadow spittle-bug. Jour. Econ. Ent. 50(3):346-347. 1957.
- Kreitlow, K. W. and O. J. Hunt. Effect of virus infection on flowering and seed production of Ladino white clover. Phytopath. 47:526-527. 1957.
- Larrabee, W. L. and M. A. Sprague. Preservation of forage nutrients as silage in gas-tight enclosures of polyvinyl chloride plastic. Jour. Dairy Sci. XL:800-809. 1957.
- Larson, L. W. Handling chopped hay with an elevator and conveyor, Section VI and silo filling with an elevator, Section VIII, 1956 Progress Report to the New York Farm Electrification Council.
- Lowe, C. C. Research effect upon trends in farm seed usage - northeastern states. Proc. 2nd Annual Farm Seed Industry-Research Conf. 2:40-45. 1957.
- Metzger, H. B. Does grass silage pay? Maine Farm Research, July 1955.
- _____. Costs of forage production and utilization on Central Maine dairy farms. Maine Agr. Expt. Sta. Bul. 561. 1957.
- Miller, J. I., W. F. Brannon, J. J. Drain and J. R. Ferguson. Mixed hays, grass silage, and corn silage for steer calves and beef cows. Cornell Agr. Expt. Sta. Bul. 923. 1957.
- Montville, F. E. and Niels Rorholm. More milk per acre - more money? Rhode Island Agriculture 4:2. 1957.
- Murphy, R. P. A look at future grass and legume varieties in the northeast. Proc. 1st Annual Farm Seed Industry-Research Conf. 1:29-35. 1956.
- Newlander, J. A. and W. H. Riddell. High moisture versus wilted grass silage for raising dairy calves. Vermont Agr. Expt. Sta. Bul. 602. 1957.
- Papanos, Stanley and B. A. Brown. Poultry manure: Its nature, care and use. Storrs (Conn.) Agr. Expt. Sta. Bul. 272. 1950.
- Pasto, Jerome, John Allison and John Washko. Ground cover and height of sward as a means of estimating pasture production. Agron. Jour. 49:407-409. 1957.
- Peters, R. A. and A. J. Kerkin. Dowpon for grass control in seedling legumes. Down to Earth. Spring 1957.

- Reid, J. T., C. C. Balch, M. J. Head and J. W. Stroud. Use of antipyrine and N-acetyl 4-aminoantipyrine in the measurement of body water and the intraluminal water of the gastro-intestinal tract of living cattle. *Nature* 179:1034-1035. 1957.
- ____ and Kennedy, W. K. Measurement of forage intake by grazing animals. *Proc. 7th Int. Grassland Congress, N. Z.* 1956.
- Roberts, D. A. Natural infection of Ladino clover by the red clover vein mosaic virus. *Plant Dis. Repr.* 41:928-929. 1957.
- ____. Observations on the influence of weather conditions upon severity of some diseases of alfalfa and red clover. *Phytopath.* 47:626-628. 1957.
- Robinson, R. R., V. G. Sprague and C. F. Gross. Effectiveness of phosphate increased by banding. *Progress in Soil and Water Conservation Research No. 12.* 1957.
- Rose, W. A. Jr. Retail distribution and procurement practices for grass and legume seeds in the twelve Northeastern States as determined by a mail survey of retail seed dealers. *M.S. Thesis. Cornell Univ.* 1956.
- Routley, D. G. The component sugars of hemicelluloses of brome grass. *Ph.D. Thesis. The Pennsylvania State Univ.* 1957.
- Schertz, K. F. Fertility in relation to chromosome behavior in Bromus inermis Leyss. *Ph.D. Thesis. Cornell Univ.* 1957.
- Schneider, E. C. Conveyor feeding system for dairy cows in stanchions and in loose housing, *Progress Report No. 2. Vt. Agr. Expt. Sta. Bul. 605.* December 1957.
- ____. This is materials handling. *County Agent and Vo-Ag Teachers' Magazine.* September 1957.
- Sherwood, R. T. Physiologic races of the red clover leaf rust fungus. *Phytopath.* 47:495-498. 1957.
- Singley, M. E. New developments in self-feeder tower silos. *Proc. of the 1957 meeting of the National Silo Association, held in Syracuse, N.Y.* Baled hay can be dried on wagons. August 10, 1957.
- Sprague, M. A. Plastic cover saves 5-20 tons of silage. *New Jersey Agriculture* 39:7-16. May-June 1957.
- ____. A silo cover that works. *What's New in Crops and Soils* 9:9. August-September 1957.

- Sprague, M. A. and C. H. Reed. Progress report on the use of plastic film envelopes for the preservation of forage nutrients as silage. Mimeo. Rept. Farm Crops Dept., Rutgers Univ. July 1, 1957.
- Sprague, V. G. Greenhouse techniques in forage crops research. 28 pp. multi-lithed. 1957.
- Sproston, T. and D. C. Pease, Jr. Thermoperiods and production of apothecial initials in the fungus Sclerotinia trifoliorum. Science 125:599-600. 1957.
- _____ and _____. The influences of thermoperiods on the production of the sexual stage of the fungus, Sclerotinia trifoliorum Erik. New York Acad. Sci. 20:199-204. 1957.
- Swift, R. W. The calorie value of TDN. J. Animal Sci. 16:753. 1957.
- Toben, G. E. What the farming situation is like in northeastern West Virginia. W. Va. Agr. Expt. Sta. Bul. 397. April 1957.
- _____. Information related to pasture programs in West Virginia. W. Va. Agr. Econ. Mimeo., Sept., 1957.
- Tyler, L. J., R. P. Murphy and H. A. MacDonald. Effect of seed treatment on seedling stands and on hay yields of forage legumes and grasses. Phytopath. 46:37-44. 1956.
- Vuckovic, B. Effect of nitrogen fertilization and cutting treatment on brome grass, Bromus inermis Leyss. M.S. Thesis. Rutgers Univ. 1957.
- Wakefield, R. C. Fertilize Ladino. Rhode Island Agriculture 3:2. 1957.
- _____, D. A. Schallock, M. Salomon and C. E. Olney. Yield and chemical composition of Ladino clover as affected by fertilizer treatments. Agron. Jour. 49:374-377. 1957.
- Whitney, A. S. The influence of some seed characteristics on germination, depth of sowing, emergence and early growth of birdsfoot trefoil. M.S. Thesis. Cornell Univ. 1957.
- Wood, G. M., R. T. Smith and D. C. Henderson. Birdsfoot trefoil meal as a substitute for alfalfa meal in a chick starter mash. Poultry Sci. 36:1098-1099. 1957.
- Wrisley, M. D. and R. H. Tremblay. Roughage on Vermont dairy farms. Vt. Agr. Expt. Sta. Bul. 604.



